

**2012 ANNUAL COMPREHENSIVE REPORT
OF GROUND AND SURFACE WATER QUALITY
GREENFIELD ENVIRONMENTAL MULTISTATE TRUST
FORMER TRONOX SODA SPRINGS, IDAHO FACILITY**

April 10, 2012

Prepared by:



GLOBAL ENVIRONMENTAL TECHNOLOGIES L.L.C.

SALT LAKE CITY, UTAH

USEPA SF



1420214

RECEIVED

APR 13 2012

OFFICE OF
ENVIRONMENTAL CLEANUP

**2012 ANNUAL COMPREHENSIVE REPORT
OF GROUND AND SURFACE WATER QUALITY
GREENFIELD ENVIRONMENTAL MULTISTATE TRUST
FORMER TRONOX SODA SPRINGS, IDAHO FACILITY**

April 6, 2012

Prepared by:



GLOBAL ENVIRONMENTAL TECHNOLOGIES L.L.C.

SALT LAKE CITY, UTAH



GLOBAL ENVIRONMENTAL TECHNOLOGIES L.L.C.

April 6, 2012
Marc Weinreich, Vice President
Greenfield Environmental Multistate Trust LLC
1928 Eagle Crest Drive
Draper, UT 84020

**RE: TRANSMITTAL: REMEDIAL ACTION 2012 ANNUAL COMPREHENSIVE
REPORT OF GROUND AND SURFACE WATER QUALITY - GREENFIELD
ENVIRONMENTAL MULTISTATE TRUST - FORMER TRONOX SODA
SPRINGS, IDAHO FACILITY**

Dear Marc:

Enclosed please find transmitted the Remedial Action 2012 Annual Comprehensive Report of Ground and Surface Water Quality for the Tronox Soda Springs, Idaho Facility. This document consist of: 1) an evaluation of the most currently available (July and October 2011) ground water quality distribution at on- and off-site locations for selected parameters; 2) an evaluation of ground and surface water quality changes with time; 3) projected decay trends for selected COC and wells for the period between 1997 and 2011 and a second set spanning 2004 through 2011, and; 4) conclusions regarding the effects to ground water from remedial actions and reclamation efforts to date. We have included an executive summary as an introduction to this year's report and findings.

We appreciate the opportunity to work with you on this project. If you have any questions regarding this transmittal, please contact us.

Very truly yours,
Global Environmental Technologies, LLC

John S. Brown, P.G., L.P.I.
Principal/Owner



Attachments: Remedial Action 2012 Annual Comprehensive Report of Ground and Surface Water Quality

xc: Bill Ryan — EPA Region X — (4 hard copies; 4 -CD copies)
Doug Tanner — IDEQ Pocatello —hard copy/CD copy
Dean Nygard — IDEQ Boise - hard copy/CD copy
Clyde Cody - IDEQ Boise - hard copy/CD copy
Tim Mosko - CH2MHILL - CD Copy
Ty Griffith - LG, LHG Greenfield Environmental Multistate Trust LLC - CD Copy

TABLE OF CONTENTS

<u>Section</u>	<u>Page No.</u>
Executive Summary.....	ES-1
1.0 INTRODUCTION.....	1
1.1 Ground Water Monitoring Program.....	1
1.2 Remedial Action Completion.....	2
1.2.1 Liquid Source Elimination.....	3
1.2.1.1 Scrubber Pond.....	3
1.2.1.2 S-X Pond.....	4
1.2.1.3 Calcine Pond.....	4
1.3 LSE Completion.....	5
1.4 Ground Water COCs.....	5
2.0 SUMMARY OF SITE HYDROGEOLOGY.....	7
2.1 Site Hydrogeology.....	7
2.1.1 Salt Lake Formation.....	7
2.1.2 Alluvium.....	8
2.1.3 Basalt Aquifer.....	8
2.1.3.1 Hydraulic Conductivities of Basalt Aquifer.....	9
2.1.3.2 Estimated Ground Water Velocities.....	10
2.2 Direction and Rate of Ground Water Flow.....	11
2.3 Site Water Levels and Site Precipitation.....	12
3.0 GROUND WATER SAMPLING.....	13
3.1 Ground Water Point of Compliance.....	13
3.2 Ground Water Sampling and Analysis Plan.....	13
3.2.1 Low-Flow Purge Sampling Methods.....	14
3.3 QA/QC Data Review	15
4.0 CURRENT GROUND AND SURFACE WATER QUALITY.....	16
4.1 Background Water Quality and Type.....	16
4.2 Common Ion Distributions in Ground Water.....	17
4.3 General Ground Water Quality Parameters.....	17
4.3.1 pH.....	17
4.3.2 Total Dissolved Solids.....	18
4.3.3 Turbidity.....	18
4.4 Selected Major Ions in Ground Water.....	19
4.4.1 Chloride.....	19
4.4.2 Nitrate Plus Nitrite.....	19
4.4.3 Sulfate.....	20
4.5 Selected Metals in Ground Water.....	21
4.5.1 Arsenic.....	21
4.5.2 Manganese.....	21
4.5.3 Molybdenum.....	21
4.5.4 Vanadium.....	22
4.6 Organic Compounds in Ground Water.....	23

TABLE OF CONTENTS (Continued)

<u>Section</u>	<u>Page No.</u>
4.6.1 Total Petroleum Hydrocarbons.....	23
4.6.2 Tributyl Phosphate.....	23
5.0 CONCENTRATION TRENDS WITH TIME.....	25
5.1 General.....	25
5.1.1 Fate and Transport of Graphed Chemical Parameters.....	26
5.2 Trends for On-Site and Point of Compliance Wells.....	28
5.2.1 Common Ions and General Indicators.....	28
5.2.2 Metals Concentration Trends.....	34
5.2.3 Organics.....	38
5.2.4 Conclusions of On-Site Well Concentration Trends.....	39
5.3 Off-Site Well Concentration Trends.....	40
5.3.1 Common Ions and General Indicators.....	41
5.3.2 Off-Site Metal Concentration Trends.....	42
5.3.3 Organics.....	44
5.3.4 Conclusions of Off-Site Well Concentration Trends.....	44
5.4 Off-Site Surface Water Quality Concentration Trends.....	45
5.4.1 Common Ions and General Indicators.....	46
5.4.2 Metals Concentration Trends.....	48
6.0 PROJECTED CONCENTRATION DECAY TRENDS	50
6.1 General	50
6.2 Results of Regression Analysis	51
6.2.1 Analytical Method.....	53
6.2.2 Results of Trendline Analysis.....	54
7.0 CONCLUSIONS.....	56
8.0 RECOMMENDATIONS.....	60
9.0 REFERENCES.....	63

TABLES

<u>Table Number</u>	<u>Title</u>
Table 1-1	Monitor Well Construction Data
Table 1-2	Maximum Concentrations of COC and Most Current Concentrations in Wells and Off-Site Springs
Table 3-1	Sampling History and Sampling Rationale for Remedial Design/Remedial Action Ground Water Sampling
Table 5-1	Chronology of Process Changes

TABLES (cont.)

<u>Table Number</u>	<u>Title</u>
Table 6-1	Projected COC Trends Based on November 1997 through September 2011 Data
Table 6-2	Projected COC Trends Based on May 2004 through September 2011 Data
Table 8-1	Long-Term Ground and Surface Monitoring Recommendations

FIGURES

<u>Figure Number</u>	<u>Title</u>
Figure 1-1	Approximate Trust Property Boundary Map
Figure 1-2	Contours of Ground Water Level Elevations – July 2011
Figure 2-1	Annual Precipitation – Soda Springs, Idaho 1990 through 2011
Figure 2-2	Water Levels Versus Time, Tronox On-Site Wells Following LSE and Pond Reclamation
Figure 4-1	pH in Ground Water – July 2011
Figure 4-2	TDS in Ground Water – July 2011
Figure 4-3	Chloride in Ground Water – July 2011
Figure 4-4	Nitrate plus Nitrite in Ground Water – July 2011
Figure 4-5	Sulfate in Ground Water – July 2011
Figure 4-6	Concentrations of Arsenic in Ground Water – July 2011
Figure 4-7	Concentrations of Manganese in Ground Water – July 2011
Figure 4-8	Concentrations of Molybdenum in Ground Water – July 2011
Figure 4-9	Concentrations of Vanadium in Ground Water – July 2011

APPENDICES

**APPENDIX A- GRAPHS OF GROUND AND SURFACE WATER QUALITY
VERSUS TIME**

**APPENDIX B- COC CONCENTRATION TRENDS WITH TIME AND
PROJECTED TRENDS**

EXECUTIVE SUMMARY

Kerr-McGee operated a vanadium plant between 1963 and January 1999. Ground water contamination originating from former plant operations was investigated during a Remedial Investigation/Feasibility Study conducted between 1991 and 1996. Ground water contaminants of concern (COC) demonstrating health risks from human consumption included arsenic, manganese, molybdenum, tributyl phosphate, total petroleum hydrocarbons and vanadium.

Most of the site-related contaminants were identified in the ground water beneath property owned by Kerr-McGee. However, molybdenum and vanadium migrated from the site in the ground water to properties off-site that are not currently controlled by the previous site owners at concentrations that exceed risk-based concentrations (RBC).

The EPA-selected remedy for the Kerr-McGee Chemical Superfund Site was to eliminate liquid discharges from plant operations, utilize and consume stockpiled waste products in the vanadium process and cap some of the on-site waste product (calcine). Calcine is the solid waste product from the vanadium leaching circuit. The remedy also required semiannual monitoring of the ground water monitoring wells and selected surface water sites and an annual comprehensive evaluation of those results to verify successful implementation of the site remedy.

Industrial ponds were taken out of service between 1995 and 1997. The remedy to eliminate process liquid discharges from vanadium operations to the ground water was completed in 1997. Kerr-McGee constructed an engineered on-site landfill in 1997 and removed sediments from two of the largest waste ponds and compacted these wastes in the landfill. Conditions beneath these ponds were never investigated during the RI/FS, and current ground water results suggest that these are areas that continue to contribute site contaminants to ground water.

Kerr-McGee failed in its attempt to process the calcine tailing into a marketable fertilizer product. The revised remedy and amended Record of Decision allowed for capping of about 22 acres of calcine waste on the east side of the industrial facility. A significant volume of calcine and other industrial wastes from vanadium processing remain in place and untreated across the industrial site. The vanadium plant that was dismantled in 2002 remains one potential source of COC to ground water but the site remains unmonitored. One 10-acre pond containing more than 20,000 yards of vanadium process wastes and liquids currently remains active to the east of the capped calcine.

In September 2002, EPA completed the first 5-year review for the site and concluded that contaminant levels in the ground water decreased at most locations following remedy implementation. Following the period of this 5-year review, the rate of concentration change in the ground water slowed considerably. In some cases, ground water concentrations increased, or spiked around 2006. Based on these observations, the second 5-year review completed during 2007 stated that a protectiveness determination of the remedy could not be completed because levels of COC in ground water and surface water remained above cleanup goals, and concentrations appeared to increase in some locations. COC trends, such as those noted near the uninvestigated pond basins and at other locations called into question whether achieving the cleanup goals for the site in the foreseeable future in absence of further actions was possible.

Ground water monitoring since completion of the remedy shows that the largest continued impacts to ground water occur near the former scrubber and S-X pond basins. Seasonal concentration trends in some well locations appear to correlate with changes in water levels and annual precipitation rates, suggesting leaching from uncontrolled wastes to ground water continues to occur following wet periods.

Organic compounds have decreased since the elimination of the ponds, but continue to exceed risk-based concentrations (RBC). Concentrations of arsenic in ground water exceed standards near the former S-X and scrubber ponds. Manganese concentrations decreased with time in nearly all wells following 1997. Manganese

concentrations are found above the RBC and continue to increase in two wells monitoring the former S-X and scrubber ponds.

Off-site springs (Finch and Big Springs) which were impacted from site operations fell below the RBC for molybdenum in 2009 and continue to remain below the RBC. Vanadium concentrations in Finch Spring remain elevated but are less than the RBC, while vanadium is less than the reporting limit in Big Spring. The City of Soda Springs water supply does not appear to be impacted from vanadium and molybdenum based on 2011 water quality results, but data suggest that nitrate concentrations are climbing at these locations and are larger than previous results.

Vanadium and molybdenum continue to exceed clean up levels at most of the monitoring wells with limited exceptions. Regression analysis suggests that ground water concentrations of molybdenum and vanadium in the wells monitoring the former S-X and scrubber ponds will exceed the clean up levels for at least 20 or more years following the remedy. This period of time is longer than previous modeling estimates and indicates a strong likelihood that that unmitigated on-site wastes will continue to impact ground water. Vanadium is projected to exceed the RBC in most wells for a considerably longer period than molybdenum and in some cases the time to reach clean up levels cannot be projected with certainty.

Based on the results of this annual review and continued ground water exceedences of health-based parameters off-site, additional site investigations are recommended to assess unmitigated plant-site sources that are contributing to elevated or spiking concentrations to the ground water potentially caused by measured increases in annual moisture noted in 2006 and in 2011. Additional monitor well installation is also recommended to assess whether deeper ground water is impacted off-site and to ensure that off-site migration pathways of site contaminants have been addressed in areas to the south of the cap, former scrubber pond and the 10-acre pond.

1.0 INTRODUCTION

1.1 Ground Water Monitoring Program

Tronox (formerly Kerr-McGee) monitored water levels and water quality in both on- and off-site wells and selected springs on a semiannual basis through 2011. The property was transferred on 14th day of February, 2011 from Tronox as debtors and debtors in possession in the Bankruptcy Cases to the Greenfield Environmental Multistate Trust LLC (Trust) in its representative capacity as Multistate Trustee.

Data reports with sample results are presented to the EPA and IDEQ on a semiannual basis. Validation reports that included the 2010 data incorporated into the Remedial Design/Remedial Action (RD/RA) database were issued to EPA, IDEQ and the Trust on August 9, 2011 and on November 30, 2011. The database is not included in this report, and the reader should refer to the data contained within the validation reports in conjunction with this document. The RD/RA database contains all sample analytical data supplied by the laboratory following the completion of the Remedial Investigation/Feasibility Study (RI/FS) study, and was prepared at the request of Region 10 EPA on September 23, 1997.

Monitor wells were installed at strategic locations to monitor specific surface water impoundments, aquifer units, downgradient off-site locations, and the Trust facility as a whole. Locations of on- and off-site well placements and screen location depths are shown in Table 1-1. These data are also presented in previous technical memoranda and work plans (Dames & Moore, 1991 a, b and 1992), (GET, 2010).

Location of the Trust site and property owned by Trust is shown on Figure 1-1. Locations of all monitoring wells installed during the remedial investigation (RI) are shown on Figure 1-2. Figure 1-2 also presents measured water level elevations and ground water gradients in July 2011.

Thirteen (13) of the eighteen (18) RI/FS wells are designated "shallow" wells with total depths of 45 to 73 feet. Four wells are designated "intermediate-depth" wells with total depths of 100 to 173 feet. One well (KM-19) is completed on-site to a total depth of 230 feet and designated as a "deep" well as it fully-penetrates the basalt bedrock sequence.

The shallow wells are completed with 10 feet of well screen that is set in the uppermost-defined basalt flow or interflow zone. Shallow wells were completed within the first occurrence of ground water that was encountered while drilling. On-site shallow wells include wells KM-1, KM-2, KM-3, KM-4, KM-5, KM-6, KM-7, KM-8, KM-9, and KM-13. Off-site shallow wells include KM-15, KM-16 and KM-17.

The intermediate-depth wells are completed with 20 feet of well screen that is set in a deeper basalt flow identified across the site through geophysical interpretation. On-site intermediate depth wells include KM-10, KM-11, and KM-12. The off-site intermediate-depth well is designated KM-18.

1.2 Remedial Action Completion

A complete discussion of the Remedial Action Completion activities is described in the Draft Remedial Action Completion Report Revision I (GET, 1999), and the Draft Remedial Action Completion Report for Calcine Capping, 2000 through 2001 (GET, 2003). Remedial Action for the Kerr-McGee vanadium facility addressed the selected site remedy from the Record of Decision (ROD, September 1995) and subsequent amendment to the ROD (July 2000). The Remedial Action for the vanadium plant included:

- Elimination of uncontrolled liquid discharges from the site;
- Landfilling solids from the scrubber and S-X ponds at an on-site landfill;
- In-place capping of the wind-blown calcine, roaster reject, reject fertilizer, and active calcine tailings during 2000 and 2001;

- Semi-annual ground water monitoring to determine the effectiveness of source control, and;
- Establishment of institutional controls in affected off-site areas to prevent ingestion of ground water for as long as the ground water exceeds the risk-based concentrations (RBC).

1.2.1 Liquid Source Elimination

The ROD required Kerr-McGee Chemical to implement Liquid Source Elimination (LSE) to eliminate the uncontrolled releases of process water to ground water. During 1993, the unlined magnesium ammonium phosphate (MAP) ponds were removed from service and covered. This action had an immediate effect on water quality in nearby well KM-5. Three larger unlined ponds at the facility were either eliminated or replaced to accomplish LSE between 1995 and 1997. These three ponds included the roaster scrubber pond, S-X raffinate pond, and the calcine pond (s). Elimination of these ponds also had an effect on ground water quality

1.2.1.1 Scrubber Pond

Wet scrubbers controlled air emissions from the vanadium roasters since the plant began operating in 1963. The solids collected in the scrubbers and in the discharge water were pumped to various scrubber water ponds. This management practice resulted in an uncontrolled release of the process water to ground water, and left the solids from the process impounded in each pond. The scrubber sediments from the former pond on the east side of the facility were impounded in the on-site landfill, constructed during 1997.

The wet scrubbers were replaced by a baghouse system on each roaster in 1997. The baghouse collected particulate emissions without the use of water. Solids collected in the baghouse were impounded with the calcine. The result of the installation of the baghouse system was the elimination of the scrubber pond. This allowed for the

excavation and placement of the roaster scrubber solids in the landfill and the closure and reclamation of the roaster scrubber pond.

The vanadium plant and supporting baghouse facilities were dismantled between October 2001 and February 2002. The footprint of the vanadium plant was covered with limestone fines and recontoured to provide positive drainage away from the site of the former facility.

1.2.1.2 S-X Pond

Kerr-McGee constructed 20 acres of double-lined ponds in 1995 and 1997 to contain the S-X raffinate stream. Use of the unlined S-X pond was discontinued by 1996 and the sediment was pushed into a pile when the bottom was dry. The S-X pond sediments were excavated from the pond and impounded in the on-site constructed landfill in 1997. The 5-acre ponds were reclaimed in 2004, while the 10-acre pond still remains at the site and contains the plant wastes excavated from the two storm water ponds and the two 5-acre ponds.

1.2.1.3 Calcine Pond

Historically, calcine was deposited in the impoundment area by mixing the solids from the vanadium leaching process with water and pumping the slurry to the calcine impoundment. The water used in this operation infiltrated through unlined calcine ponds. Kerr-McGee installed a mechanical dewatering system to separate the water and the calcine in 1997, eliminating the pond. No calcine was produced following closure of the plant in 1999 and the calcine impoundment on the east side of the site was capped with a synthetic cover in 2001. Calcine ponds on the west side of the site remain uncapped.

1.3 LSE Completion

The S-X pond was taken out of service during 1996. During November 1996, the S-X pond sediments and underlying soils were dozed to the south end of the pond and covered with plastic. This action allowed an extended period for the S-X solids to dry and consolidate.

The scrubber pond was taken out of service in April 1997 and was drained prior to the sediment thickness investigation. The scrubber solids were worked into windrows and piles in the scrubber pond basin to accelerate drying.

Kerr-McGee excavated and transported S-X and scrubber pond sludge to an engineered landfill constructed during September 1997. Prior to compaction in the landfill, the wastes were mixed at a ratio of 3:1 scrubber to S-X solids to achieve optimum moisture for compaction. During the last week of September 1997, the Idaho Department of Environmental Quality (IDEQ) inspected the pond basins and determined that all of the pond solids had been removed from the native soils lining the pond basins. Several feet of clean native soil were placed in the pond basins to support growth of a vegetative cover. The overall site slopes were graded and sloped to promote runoff away from the preexisting pond locations.

Pond reclamation activities occurred during the last week of September and during the first week of October 1997. Following removal of sediment materials from the pond basins and approval of closure from the IDEQ, completeness of sediment removal from pond basins was documented with photographs.

1.4 Ground Water COC

The six contaminants of concern (COC) that were identified in the Risk Assessment (EPA, 1993) include arsenic, manganese, molybdenum, tributyl phosphate, total

petroleum hydrocarbons, and vanadium. Table 1-2 presents a range of concentrations for COC at the POC wells, showing both the largest and the most recent (October 2011) concentrations.

2.0 SUMMARY OF SITE HYDROGEOLOGY

2.1 Site Hydrogeology

Ground water beneath and downgradient from the Trust site is found within the basalt sequences, the basalt interflow zones, and within limited areas of the alluvium. Ground water also exists within the Tertiary Salt Lake Formation that underlies the basalt. All of the on-site and off-site monitor wells installed as part of the Kerr-McGee RI/FS are completed at various depths within the basalts and basalt interflow zones, as shown in Table 1-1. Although ground water occurs in the Salt Lake Formation and within a limited area of the alluvium on-site, the basalts are considered the principal aquifer beneath the Trust site and the Monsanto site to the west. Monsanto production wells extract ground water from the basalt aquifer.

The hydrogeologic properties of the basalts and interflow zones were characterized during the Kerr-McGee RI/FS, using:

- Geologic, geophysical, hydraulic head, hydraulic gradient, and hydraulic conductivity parameters from the installed wells;
- Hydraulic response data observed in the monitor wells, and;
- Observation and testing data from 14 on-site monitor wells, 4 off-site monitor wells and 5 on-site coreholes.

2.1.1 The Salt Lake Formation

The Tertiary Salt Lake Formation is comprised of tuffaceous sandstones, conglomerates and limestones that yield small amounts of ground water for domestic and stock purposes, and are unpredictable as a water-supply source. The Salt Lake Formation is not considered part of the shallow ground water system. The Salt Lake Formation was investigated on-site in corehole CH-3 from 231 to 250 feet (total depth of corehole CH-3) and was found to consist of fractured quartzite, sandstone, and clay. Packer testing resulted in a hydraulic conductivity determination of 0.77 ft/day. This result is within, but

at the low end of the range of packer-test hydraulic conductivities estimated for the deeper part of the overlying basalt sequence. No wells at the Trust site are completed within the Salt Lake formation.

2.1.2 Alluvium

Seismic refraction studies and drilling performed as part of the RI indicated that alluvium is thickest and extends to the greatest depth on the eastern side of the plant facility. Based on geologic data from well KM-2, an area of thin saturated alluvium overlies the basalt in the eastern part of the Trust facility where the elevation of the basalt/alluvium contact falls below the elevation of the water table. Well KM-2 is screened across the basalt/alluvium contact. The area of saturated alluvium appears to be limited near the east side of the facility, extending to the north and south of the capped calcine tailings. The alluvium has not been noted to contain ground water at other locations on the Trust site.

2.1.3 Basalt Aquifer

The basalts and interflow zones of the mid-Pleistocene Blackfoot Lava Field comprise the principal aquifer beneath the site. All of the on-site monitor wells, with the exception of well KM-2, are screened exclusively within these basalts and interflow zones. The basalt sequence at the site, described in the RI is comprised of five identifiable basalt flows (Basalts Nos. Qb₁ through Qb₅) and associated interflow zones (Interflow Zones Nos. I₁ through I₄). Two younger basalts (Qb_{5a} and Qb_{5b}) and associated interflows were identified to the south and west of the site and are believed to have occurred as post-faulting flows. These basalts and interflow zones are believed to be stratigraphically similar to basalt flows identified at the Monsanto Site by Golder (1985 and 1992a). However, the hydrogeologic characteristics of the basalt flows between the two sites appear to be different. Notable differences include:

- Magnitudes of hydraulic conductivities of the basalt flows and interflow zones at the site are relatively similar based on the results of extensive aquifer testing, whereas basalts and interflow units at the Monsanto site are indicated to differ substantially;
- Local water level elevation and water quality differences exist between adjacent shallow, intermediate-depth and deep wells at Monsanto. Water quality and aquifer test data for the Trust site indicate that the entire thickness of saturated basalt is in relatively good vertical hydraulic connection over the area of the Trust site, and;
- Faults are considered to represent zones of increased transmissivity at the Trust site, whereas they are interpreted to be barriers to flow at the Monsanto site.

2.1.3.1 Hydraulic Conductivities of the Basalt Aquifer

Primary permeability of unbroken basalt is small. Most ground water in the basalt aquifer is transmitted along secondary features such as joints or fractures. Vertical columnar joints are a common feature observed in basalt exposed to the south and southwest of the site along the trace of the Finch Spring Fault. The presence of intensely fractured or vesicular zones, rubble zones, and/or cinder zones can also greatly increase the ability of basalt to transmit water. Interflow zones are comprised of sub aerial deposited materials, including clays, cinderaceous deposits, alluvial sands and gravels, organic debris and weathered and broken basalt. Variations in the ability of interflow zones to transmit water result from changes in the character and thickness of these materials.

Observed hydraulic conductivities estimated from the slug, specific capacity, and pumping tests conducted in the shallow, intermediate-depth, and deep wells include the following:

- Basalts ranged from 8 to 340 ft/day;
- Interflow zones ranged from 90 to more than 200 ft/day.
- Basalts and interflow zones together ranged from 2 to more than 100 ft/day.
- Basalt No. Qb₅ (shallow basalt represented by shallow well screened zones) ranged from about 9 to 340 ft/day.

- Basalt No. Qb₃ (Deeper basalt screened in wells KM-10, KM-11, KM-12, and KM-18) ranged from 8 to almost 100 ft/day.

Hydraulic conductivities estimated for well KM-19 screened in Basalt No. Qb₂ and Interflow Zone No. I₁ ranged from about 15 to almost 70 ft/day. Results are presented in Table 1-1.

Generalizations about hydraulic conductivities observed within the basalt aquifer at the site include the following:

- The hydraulic conductivities of interflow zones are not significantly greater than those of the basalt flows;
- Hydraulic conductivities of the shallower basalts (Basalt No. Qb₅) are generally greater but not significantly greater than those of the deeper basalts (Basalt No. Qb₃);
- A horizontal layer of significantly smaller hydraulic conductivity which could greatly limit or prevent vertical movement of ground water was not identified;
- A continuous horizontal layer of significantly larger hydraulic conductivity along which horizontal ground water flow could be localized was not identified;
- Hydraulic conductivities in the shallow wells on the east side of the plant (KM-1, KM-2, KM-3, and KM-4) range from 90 to 270 ft/day and appear to be greater than hydraulic conductivities in shallow wells on the west side of the plant (KM-5, KM-8, KM-9, and KM-13), which range from 9 to 48 ft/day.

2.1.3.2 Estimated Ground Water Velocities

Horizontal hydraulic gradients within the shallower basalt aquifer vary from 0.01 feet per foot in the eastern part of the site to 0.03 feet per foot in the western part of the site. Effective porosities have been reported for the basalts of the Snake River Plain aquifer of southeastern Idaho to range from about 8 to 10 percent (Robertson, 1974; Lewis and Goldstein, 1982; Isherwood, 1981; Nace et al., 1959). If an effective porosity of 8 percent and range of hydraulic conductivities of 5 to 270 ft/day is used, then a range of estimated ground water particle velocities of 0.6 to 34 ft/day can be calculated for the eastern part of the plant site. The effective porosity of 8 percent and the observed range of hydraulic

conductivities of 9 to 340 ft/day on the western of the site yield a range of estimated ground water particle velocities of 3 to 130 ft/day for the western part of the plant site, as shown in Table 1-1.

2.2 Current Direction and Rate of Ground Water Flow

Ground water flows in response to hydraulic gradients from areas of higher hydraulic head to areas of lower hydraulic head at rates that are proportional to hydraulic conductivity and hydraulic gradient and inversely proportional to effective porosity of the aquifer. Ground water can flow vertically through aquifers or between aquifers in response to vertical hydraulic gradients and horizontally within aquifers in response to horizontal gradients. Ground water in the Shallow Aquifer System generally flows southward from the topographically higher Blackfoot Reservoir (about 12 miles north of the Trust facility) to seeps and springs along the topographically lower Bear River.

Horizontal hydraulic gradients and ground water flow directions within the shallow basalt units at the site are indicated by water level elevations measured during July 2011 and are contoured on Figure 1-2. Site gradient averaged about 0.02 ft/ft in 2011.

The predominant flow direction beneath the plant site is to the west-southwest, as shown on Figure 1-2. The western ground water flow direction beneath the site is induced by pumping from the Monsanto production wells located west of the Trust site. Ground water levels beneath the east side of the facility suggest a south-southwesterly flow component, with flow beneath the former scrubber pond and calcine cap directed towards well KM-3.

Water level elevations measured during July 2011 in the deeper monitor wells KM-11, KM-12, and KM-18 are also shown on Figure 1-2 but are not contoured. Ground water levels in the deeper wells suggest a pattern of ground water flow that is similar to the pattern observed in the shallow wells.

2.3 Site Water Levels and Site Precipitation

Figure 2-1 presents annual rainfall totals for Soda Springs, Idaho between 1990 and 2011, obtained from Tigert Airport in Soda Springs. Annual totals peaked at about 17.5 inches in 1994 and 1997. Annual precipitation rates declined between 1997 and 2001 to about 11.5 inches. Annual precipitation rates increased on average between 2001 and 2005, to just over 15 inches on an annual average. Since 2004, only one year (2007) was substantially below the 14.9 inch annual average. Approximately 14.8 inches of moisture were recorded in 2011.

Figure 2-2 shows the ground water level elevations in the monitor wells. Water levels are notably seasonal. Water levels are typically higher by about 2 to 3 feet in the spring when compared with the fall water levels. In general, water levels show a decreasing trend between 1997 and 2005. The trend has been an overall rise between 2005 and 2011. Site ground water level changes over time correlate with variation in the annual average precipitation rates, although general long-term rises in site water levels lag the precipitation by about three years, based on the observation of the low annual average in 2001 and recovery in water levels in site wells after 2004. Overall, water levels dropped on average 5 to 8 feet between 1997 and October 2001, and then remained at lowered levels through 2004, as indicated on Figure 2-2. Water levels recovered somewhat between 2004 and 2011 as a result of the increased annual moisture as shown on Figure 2-1. A spike in water levels is noted in 2006. During 2011, the net seasonal change in water levels was smaller than previously observed seasonal differences. .

3.0 GROUND WATER SAMPLING

3.1 Ground Water Point of Compliance

The Record of Decision (EPA, September 1995) stated that the point of compliance (POC) for the evaluation of the selected remedial actions for ground water will be the boundary of the current active industrial facility, using the existing monitoring wells (EPA, 1995). During the RI, Kerr-McGee placed monitor wells at strategic locations to monitor specific impoundments, aquifer units, downgradient off-site locations, and the facility as a whole. Locations of on- and off-site well placements and screen location depths are shown on Table 1-1 and were presented in previous technical memoranda and work plans.

During 2004, Kerr-McGee purchased the Hopkins property to the south of the former industrial facility. This property includes the land containing the monitoring wells KM-15, KM-16, KM-17, and KM-18, that have been designated the "off-site" wells in all previous documents. The off-site designation throughout this document refers to these four wells that are located south of the industrial facility, as previously established.

POC wells include wells KM-2, KM-3, KM-5, KM-8, KM-9, KM-11, KM-12, KM-13, and KM-19. EPA requested the addition of wells KM-2, KM-3 and KM-11 to the list in their May 6, 1997 correspondence and Tronox included POC sampling for these wells. Table 3-1 provides the current justifications used for sampling of POC wells at the site, and for sampling off-site well and spring locations.

3.2 Ground Water Sampling and Analysis Plan

A ground and surface water sampling plan was developed for the RD/RA sampling events for on-going semiannual sampling. This plan was finalized and accepted by EPA during May 1997. An additional low-flow sampling plan was developed during September 1997 to incorporate low-flow sampling methods described below.

3.2.1 Low-Flow Purge Sampling Methods

Kerr-McGee installed stainless steel submersible pumps in each of the sampling wells during October 1997. A pump was installed in KM-7 during May 2000. These pumps are dedicated for evacuation and sampling purposes. Each pump is operated by a portable generator system. Each pump is suspended on Schedule 80 1-inch PVC piping and a stainless steel safety cable (in intermediate depth and deep wells), such that the intake level on each pump is placed in the approximate center of the well screened interval.

Low-flow well purging was first performed during the November 1997 sampling round following dedicated pump installation in each of the sampled wells. Low-flow sampling methods are based on EPA Region 1 "Low Flow SOP" dated May 13, 1996 and the EPA document "Low-Flow (Minimal Drawdown) Ground Water Sampling Procedures" dated April 1996. This method was provided as an addendum to the RD/RA Sampling and Analysis Plan (SAP) deliverable submitted to EPA during May 1997 and approved by Region 10 EPA on June 6, 1997. Low-flow sampling is performed on all of the "KM" series wells with the exception of non-POC wells KM-1 and KM-10. Wells KM-1 and KM-10 are monitored for water level purposes only, although these two wells were sampled in October 2008 and in May 2009 at the request of EPA.

During sampling, flow rates are measured concurrent with drawdown in each well to assess stabilization of purged ground water. A discharge assembly is used to control the rate of discharge from each well via use of a ball valve. The assembly is used to control discharge from each well during sampling such that the amount of discharge will not allow the well to be drawn down more than 0.3 feet during purging and sampling events.

Field measurements are made through the use of a turbidity meter and flow cell. The flow cell is used to measure pH, temperature, specific conductance, and dissolved

oxygen. Field data are graphed following sample collection to show stabilization of field parameter measurements with time prior to sample collection. These graphs are presented with the semiannual data validation reports. Criteria used to determine whether the purged water has stabilized include:

- pH within ± 0.3 units;
- Temperature to within ± 2 degrees;
- Specific Conductance within ± 10 percent;
- Dissolved oxygen within ± 10 percent, and;
- Turbidity within ± 10 percent.

If the parameters do not stabilize to meet the above criteria within the extraction of three casing volumes, then a sample is obtained following the removal of not more than three casing volumes. Samples are collected from the discharge point beyond the ball valve. Samples are collected and handled in accordance with the May 1997 SAP.

3.3 QA/QC Data Review

QA/QC review is performed on a semiannual basis after receipt of the data from the lab. Results of the QA/QC data review are presented in the semiannual data validation report, and are not included in this annual ground water review.

4.0 GROUND AND SURFACE WATER QUALITY

The July 2011 round included the collection of samples between the dates of July 7 through July 9, 2011 the (July 2011 sampling round). The October 2011 round was completed between October 17 and October 19, 2011.

4.1 Background Water Quality and Type

Upgradient wells KM-1 and KM-10 were sampled during the RI, and in the fall of 2008 and spring 2009. The results from 2009 sampling of these wells indicated that wells KM-1 and KM-10 contained vanadium and molybdenum at concentrations that were one to two orders of magnitude below the RBC. Other locations sampled from historic background included Formation Spring, and several other private wells to the north and east of the site. However, these background locations have not been sampled since 1991 because site clean-up performance is based on the POC wells and background is considered to not contain the COC. The reader is encouraged to refer to the RI report (Dames & Moore, 1995) for information on these background sites.

TDS concentrations are expected to be about 500 mg/l in background wells and springs based on historic data. The largest reported TDS concentration from background locations was 579 mg/l in Formation Spring. The pH values measured at the background locations were near neutral and ranged from 6.8 to 7.4 units. Specific conductance ranged from about 840 umhos/cm in the private wells to about 970 umhos/cm in Formation Spring.

Reported background chloride concentrations were about 3.9 mg/l. Background sulfate concentrations are in the range of about 40 mg/l. Nitrate concentrations ranged from 0.11 mg/l in Formation Spring to 0.75 mg/l in private wells. Concentrations of aluminum, arsenic, chromium, manganese, molybdenum, nickel, selenium, and vanadium were less than detection at upgradient private wells and springs located to the east of the site.

Background ground water quality and type was characterized during the RI using the trilinear diagram classification method developed by Piper (1944). The Piper diagram consists of two ternary fields (triangles) for plotting percentages of cations (left triangle) and anions (right triangle), and a central diamond-shaped composite field for plotting the relative contribution of the major ion pairs. Based on the Piper plots, the site background water type plots in a specific pattern and can be classified as calcium-magnesium bicarbonate-type water.

4.2 Common Ion Distributions in Ground Water

The Piper plots evaluated during the RI indicated a mixing of background-type waters beneath the site with pond seepage and contributions from leachate produced by uncontrolled sources in the vadose zone. Ground water flowing onto the site is relatively high in calcium and low in sodium and potassium. Waters are also compositionally high in bicarbonate. Waters mixed beneath the site increase substantially in sodium, potassium, sulfate and chloride (Dames & Moore, 1995) from the effects of pond seepage.

4.3 General Ground Water Quality Parameters

4.3.1 pH

The pH range in wells across the site historically indicated neutral to slightly alkaline conditions in the past. Between 1999 and 2001, field pH was lower in many of the wells near the reclaimed S-X pond including samples from wells KM-6, KM-7, KM-8, KM-12, KM-19, and near the reclaimed scrubber pond (KM-2, KM-3, KM-4, and KM-11). The lower ground water pH (range of 6.1 to 6.9) may have affected metals concentration trends during the 1999 through 2001 period, resulting in metals concentration increases during this period. Site distribution of pH is shown on Figure 4-1. The pH is generally neutral across the site, larger pH around the former scrubber pond and lower pH around the south end of the former S-X pond. During the July 2011 sampling event, pH indicated

lower pH in the vicinity of the covered S-X pond area and to the south of this area, with the lowest pH occurring in the vicinity of well KM-8.

4.3.2 Total Dissolved Solids

July 2011 concentrations of TDS are shown in Figure 4-2. July ground water TDS concentrations in the shallow aquifer ranged from 550 mg/l in well KM-13 to 7,900 mg/l in well KM-8. The secondary drinking water standard for TDS (500 mg/l) was equal to, or exceeded in the POC wells. TDS is elevated in shallow wells surrounding the reclaimed scrubber pond, located to the south of the calcine tailing area that was capped in 2001. Concentrations of TDS in intermediate-depth well KM-11 is within the range of background. Beneath the west side of the site, TDS concentration in well KM-8 is substantially larger than nearby wells KM-9 and KM-13 which are slightly less than background TDS concentrations. TDS is elevated above background in wells KM-6 and intermediate depth well KM-12 near the S-X pond. TDS concentration in deep well KM-19 (490 mg/l) is within the assumed background concentration range.

At off-site ground water locations, TDS concentrations are elevated in wells KM-15 through KM-18, ranging from 590 to 780 mg/l. Finch Spring, located approximately 4400 feet south of the Trust site, indicates a TDS concentration of 520 mg/l, while Big Spring indicates slightly larger concentration of 580 mg/l.

4.3.3 Turbidity

Turbidity was measured in the field during low-flow purging of the wells. Results of turbidity for the 2010 sampling events are summarized in Table 1 and presented graphically in Appendix A of the July 2011 Laboratory Data Quality Report (GET, August 19, 2011). Although turbidity is generally not considered an indicator of ground water contamination, excessive turbidity in an unfiltered sample can bias analytical results causing reported total metals concentrations to be unrepresentative of true concentrations

in ground water. Turbidity is a measure of the solids and suspended organic material in a sample and is reported in nephelometric turbidity units (NTUs).

July 2011 turbidity ranged from 0.24 NTUs in well KM-12 to 99.5 NTUs in well KM-8. Well KM-8 frequently exhibited increased turbidity throughout its sampling history. Turbidity was reduced following re-development and removal of large amounts of sediment from this well in February 2000.

4.4 Selected Major Ions in Ground Water

4.4.1 Chloride

July 2011 concentrations of chloride are shown on Figure 4-3. The secondary drinking water standard for chloride is 250 mg/l. Chloride concentrations in shallow wells range from 24 mg/l in KM-9 to 1500 mg/l in well KM-8. Chloride was a predominant constituent in the S-X and scrubber ponds before these impoundments were removed from service. July 2011 ground water chloride concentrations are elevated relative to background near the reclaimed scrubber pond as indicated on Figure 4-3. Wells KM-9 and KM-13 located to the southwest and west of the S-X pond, respectively have near-background chloride concentrations while nearby well KM-8 is two orders of magnitude larger in concentration. Concentrations of chloride in deeper wells, including well KM-11 near the former scrubber pond and in wells KM-12 and KM-19 near the former S-X pond are smaller concentration and range from 15 to 40 mg/l. Chloride concentrations at Finch and Big Spring are 20 mg/l and 30 mg/l, respectively. Upper and Lower Ledger Spring chloride concentrations range from 5.6 to 5.9 mg/l and represent background levels.

4.4.2 Nitrate Plus Nitrite

Prior to the October 1995 sampling round, samples were analyzed for nitrate, nitrite, and nitrate plus nitrite. Results indicated that nitrite concentrations are relatively small in comparison with nitrate. Currently, only nitrate plus nitrite is analyzed. The primary

drinking water standard of for nitrate is 10 mg/l. Nitrate plus nitrite concentrations at Upper and Lower Ledger Springs nitrate-nitrite range from 0.88 to 1.3 mg/l. While this may be representative of background concentration for the basalt aquifer, the trend appears to be increasing with time.

Nitrate plus nitrite concentrations from the July 2011 sampling round are presented on Figure 4-4. Increased nitrate plus nitrite concentrations are centered about well KM-8 to the south of the covered S-X pond, and in another ground water area beneath the site centered to the south west of the calcine cap near well KM-4. Nitrate plus nitrite concentrations are found in the ground water exceeding 10 mg/l beyond the industrial facility boundary to the south and southwest of the site towards well KM-15. Nitrate plus nitrite is noted to be larger than background concentration at Finch Spring (3.5 mg/l) and at Big Spring (4.5 mg/l).

4.4.3 Sulfate

Sulfate demonstrates a similar ground water trend to chloride and TDS. Concentration distribution of sulfate in the aquifer is presented on Figure 4-5. Reported concentrations of sulfate from the July 2011 sample round range from about 57 mg/l in well KM-5 to 4900 mg/l in well KM-8. Increased concentrations are centered immediately west and south of the covered scrubber pond and to the south and west of the covered S-X pond. Sulfate concentrations in the deeper wells are elevated with respect to background concentration, and range from 45 to 100 mg/l. The secondary drinking water standard for sulfate (250 mg/l) was exceeded in monitor wells KM-3 and KM-8. The largest sulfate concentrations in ground water are associated with areas infiltrated by the former S-X raffinate stream. The former S-X raffinate stream was routed to the site of the former scrubber pond during operations. Off-site concentrations of sulfate are elevated above background in wells KM-15 through well KM-18, ranging from 76 to 150 mg/l.

4.5 Selected Metals in Ground Water

4.5.1 Arsenic

Arsenic ground water concentration ranges in Trust monitor wells are summarized in Table 1-2 and are shown on Figure 4-6. Concentrations in the on-site wells range from 0.57 ug/l to 59 ug/l in well KM-8. Observation of arsenic in on-site wells indicates that arsenic is detected in wells around the reclaimed scrubber pond. Shallow wells KM-2 and KM-3 near the former scrubber pond exceeded 10 ug/l during the July 2011 sampling round. Samples collected from off-site wells and springs indicate Finch and Big Spring levels were small (0.51 to 0.57 ug/l), near the instrument detection limit for arsenic, while Upper and Lower Ledger Springs were less than detection.

4.5.2 Manganese

Manganese concentrations are decreasing with time in nearly all of the wells. Manganese ground water concentrations in Trust monitor wells are summarized in Table 1-2, and are shown on Figure 4-7. July 2011 manganese concentrations in ground water for on-site wells ranged from 0.13 ug/l in well KM-19 to 6200 ug/l in well KM-8. The RBC for manganese (180 ug/l) was also exceeded in well KM-3 (690 ug/l) near the scrubber pond. Manganese does not exceed the RBC at any other on-site or off-site well locations. Manganese was reported to range from less than the detection limit to 0.56 ug/l at Upper and Lower Ledger Spring. Manganese was 1.6 ug/l at Finch Spring and 0.56 ug/l at Big Springs in July 2011.

4.5.3 Molybdenum

Molybdenum concentrations indicate overall decreasing trends with time. Molybdenum ground water concentrations from the most recent sampling round are summarized in Table 1-2. Concentrations from July 2011 are shown on Figure 4-8. Molybdenum was a dominant metal in the S-X raffinate stream, and therefore molybdenum is found in larger

ground water concentration near former pond sources. During July 2011, on-site well concentrations of molybdenum ranged between 16 ug/l in well KM-19 to 31,000 ug/l in well KM-8. Figure 4-8 illustrates that concentrations of molybdenum are elevated in areas centered to the south of the former S-X pond and to the south and west of the covered scrubber pond. Molybdenum exceeded the RBC (180 ug/l) in all of the sampled on-site wells in July 2011, with the exception of well KM-19. The molybdenum RBC is exceeded at all off-site Trust well locations. Finch Spring and Big Spring fell below the RBC in 2009 and remained below the RBC through 2011. Molybdenum was less than the detection limit of 20 ug/l in Upper and Lower Ledger Spring during July 2011.

4.5.4 Vanadium

Vanadium concentrations in ground water appear to be decreasing with time at most monitored locations, but at a slower rate of concentration change when compared with arsenic, manganese, and molybdenum. Ground water vanadium concentrations in the Trust monitor wells in October 2011 are plotted on Figure 4-9 from the July 2011 sampling round. Distribution of vanadium in the ground water is similar to the nitrate plus nitrite distribution.

Vanadium was a dominant metal in the S-X raffinate stream. Vanadium is detected at concentrations above the RBC (260 ug/l) in all of the on-site wells with the exceptions of intermediate well KM-11 and deep well KM-19. July 2011 vanadium concentrations in the ground water ranged between 9.7 ug/l in KM-11 to 14,000 ug/l in well KM-8. Figure 4-9 illustrates similar distribution trends to nitrate plus nitrite concentration in ground water, with the larger concentrations identified between well KM-4 near the south west corner of the calcine cap to well KM-8 to the south of the former S-X pond location. Vanadium concentrations in off-site monitor wells located southwest of the site all exceed the vanadium RBC with the exception of well KM-17 (62 ug/l) that remains substantially below the RBC for vanadium.

During July 2011, the vanadium concentration in Finch Spring was elevated (52 ug/l), but much smaller (4.3 ug/l) at Big Spring. Vanadium was 2 ug/l in Upper Ledger Springs and 2.2 ug/l in Lower Ledger Springs.

4.6 Organic Compounds in Ground Water

As noted during the RI (Dames & Moore, 1995), COC semi-volatile organic compounds that include tributyl phosphate (TBP) and total petroleum hydrocarbons (TPH) originated from the No. 1 fuel oil carrier used in the solvent extraction (S-X) process and found in the S-X raffinate stream. These compounds were detected in the former ponds and in the ground water. POC wells were sampled for total petroleum hydrocarbons and for semi-volatile compounds for the detection of TBP through 1999. Organics were sampled in all POC wells in May/June 2002 as requested by EPA for evaluation in the 5-year review. Organics are not sampled at off-site locations. Currently, only well KM-8 is sampled for organics.

4.6.1 Total Petroleum Hydrocarbons

TPH provides screening level estimates of total organic compound concentrations within certain hydrocarbon ranges but does not identify or provide concentrations of specific organic compounds. TPH was analyzed using Method 418.1 through 1999. This method could no longer be used because Freon was discontinued for use in the method by federal regulation. During the July 2011 sampling round, TPH was analyzed using a different extraction under Method SW846 8015B that included analysis for a range of C₁₀ through C₃₆. TPH concentrations in POC monitor well KM-8 during 2011 ranged from 1.2 to 1.9 mg/l, greater than the RBC (0.73 mg/l).

4.6.2 Tributyl Phosphate

TBP was used in the S-X raffinate stream and was detected at concentrations above the RBC (180 ug/l) in the wells near the reclaimed S-X and scrubber ponds during 1997.

Results of previous analyses in off-site wells suggest that TBP does not exceed the RBC downgradient of the plant facility boundary. During a number of sampling events, TBP was not detected. During 1999, TBP was detected only in well KM-8 at 1400 ug/l. During 2000 and 2001, TBP was not detected in well KM-8. It is probable that some of the unknown compounds in KM-8 may be the result of degradation of the TBP compound. In 2011, TBP ranged from 390 ug/l to 850 ug/l in well KM-8, greater than the RBC.

5.0 CONCENTRATION TRENDS WITH TIME

5.1 General

Plots of concentration versus time are shown on the graphs presented in Appendix A. These graphs of routinely sampled well and spring sites present common ion and general indicator trends, including chloride, nitrate plus nitrite, sulfate, and total dissolved solids. Metals concentration graphs include COC parameters arsenic, manganese, molybdenum, and vanadium. During 2011, graphed organic parameters include TBP and TPH from well KM-8 only because other wells were not sampled for organics.

The charts in Appendix A are annotated, where appropriate, to show periods of pond operation, the approximate time that liquid source elimination (LSE) was implemented as a remedial action, and the time that calcine capping was performed. Observed increases and decreases in ground water concentrations shown on the plots result from:

- Process changes during plant and pond operation;
- Liquid source elimination (LSE), removal of pond sediments and pond reclamation that resulted in decreased concentrations;
- Changes in ground water pH;
- Changes in annual precipitation, water ground water levels, and subsequent gradients;
- Advective transport and natural attenuation in the aquifer.

Table 5-1 provides a chronology of process events, pond management events and other site events. A number of these measures have resulted in increasing and decreasing concentrations in the wells, as well as short-term concentration increases for a few of the COCs following implementation of the site remedy.

5.1.1 Fate and Transport of Graphed Chemical Parameters

Inorganic constituents evaluated versus time include metals and common ions. Constituents can be non-reactive and move through the ground water, unaffected by biotic (metabolism, such as microorganisms) and abiotic (adsorption, ion exchange, precipitation, hydrolysis, redox) processes. The fate of specific compounds ultimately depends on the reactivity or non-reactivity of the chemical with the media during transport.

Common Ions

Graphs of the non-reactive chemicals include chloride, a member of the halogen group that is one of the most commonly detected anions in natural water. The transport of chloride through the ground water is largely through physical (hydrodynamic) processes. Chlorides travel at essentially the same rate as the ground water (Knox et al., 1993); the graphs indicate that chloride concentrations changed more quickly in response to modifications in plant and pond operations, LSE and subsequent reclamation efforts.

Chloride ions can form complexes with a few of the positively charged ionic species, however, these complexes are usually weak, and are generally considered insignificant unless chloride concentrations are very large (Hem, 1978). Chloride is considered one of the best tracer elements, and is widely used experimentally in tracer models. In general, chloride does not enter into reduction/oxidation (redox) reactions, does not form solute complexes with other ions, does not adsorb to mineral surfaces and does not form salts of low solubility.

In the absence of plant growth, nitrate behaves as a mobile anion, similar to chloride (Drever, 1988). Nitrate concentrations can be rapidly reduced in surface waters through assimilation by aquatic plants (National Academy of Sciences, 1977). Attenuating factors for nitrates do not appear significant at the site, and concentrations may be reduced primarily through dilution in the aquifer.

The sulfate ion is chemically stable, and forms salts of low solubility with only a few metals (Hem, 1978). Once sulfate has dissolved in water, it generally remains in solution except where it is anaerobically reduced to sulfide, precipitated in sediment, released to the atmosphere, or incorporated into living organic matter.

Metals

Several processes interact to control the reactivity and rate of transport of compounds in ground water. Metal ions can be strongly adsorbed to mineral surfaces in a porous medium (such as a clayey interflow zone in a basalt sequence), or to rock surfaces exposed by fractures. On the other hand, this would inhibit their transport through the aquifer when complexed with other ions; some metals can be transported at average velocities that are orders of magnitude faster than when not complexed because of changes in the attenuation properties for the complexed metal.

Changes in speciation and reactivity can result from encountering different chemistries within the aquifer. The mobilities of different oxidation states of metals such as arsenic, manganese, molybdenum, and vanadium may also differ by orders of magnitude (Allen et al., 1993).

In solution at neutral pH, the stable forms of arsenic would be arsenate oxyanions (Hem, 1978), with the dominant form being dependant on the pH of the water. Inorganic factors that maintain low concentrations of arsenic in water include adsorption by hydrous iron oxide, co-precipitation or combination with sulfide.

The transport and partitioning of manganese in water is controlled by the solubility of the specific chemical form of manganese that is present (USHHS, 1990). The solubility and speciation of manganese oxides in solution is largely a function of pH and redox potential. Manganese can also be subject to microbial activity. The principal anion associated with manganese is carbonate, although in waters with large bicarbonate concentrations, manganese bicarbonate complexes can be formed. In waters containing an excess of

1000 mg/l sulfate, manganese sulfate may become the dominant species. In extremely reduced water, the fate of manganese tends to be controlled by the formation of poorly soluble sulfide (USHHS, 1990). The tendency for soluble manganese to adsorb to soils and sediments depends largely on the cation exchange capacity and the organic composition of the soil (USHHS, 1990). Soil adsorption for manganese may be significant in the soils at the site, can be highly variable and can span five orders of magnitude, increasing as a function of organic content and ionic exchange capacity with the soil (Baes and Sharp, 1983). At small concentrations, manganese may become fixed by clays, whereas, at larger concentrations manganese may be desorbed by ion exchange with other ions in solution (USHHS, 1990).

Molybdenum is readily soluble in water, and is likely to be more mobile than vanadium in the ground water. Multiple valence states are a complicating factor in molybdenum chemistry. The anionic (molybdate) species are probably predominant in natural water (Hem, 1978).

Vanadium in the ground water at the site is predominantly found in the pentavalent state. Transport of vanadium in water and soil is influenced by redox potential, pH, and the presence of particulate (USHHS, 1990). Vanadium species have a tendency to bind strongly to mineral or biogenic surfaces by adsorption or complexing; hence it can be transported either in solution or in suspension. Adsorption may be the most significant attenuating factor at the site.

5.2 Trends for On-site and Point of Compliance Wells

5.2.1 Common Ions and General Indicators

Parameters including TDS, sulfate, and chloride indicate similar decreasing trends at the on-site non-compliance and POC wells. The pH is also a general indicator that may be affecting metals trends and concentrations noted at some locations in the past.

Based on a review of concentrations versus time for these parameters, the following general observations are made:

pH

Ground water in the vicinity of the reclaimed scrubber pond had neutral to slightly alkaline pH values through early 1999, relatively unaffected by process waters during plant operation or LSE. Following the summer of 1999, a general decrease in pH was noted in the shallow ground water through 2001 and in a few wells in 2002. The pH rose in these wells following 2002 to the neutral range in 2003. Trends between 2003 and the present indicate the ground water beneath the site is in the near-neutral range, with lowered pH in the ground water near well KM-8. The site pH trend noted in 2011 was generally neutral to slightly basic across the site from north to south.

TDS

TDS concentration trends for ground water in wells located near the former site ponds and facilities are contained in Appendix A. Wells located near the former scrubber pond indicate an increase in TDS concentrations through 1995 and then generally decreasing concentrations are indicated following remedial actions to 2011, with a flattening but decreasing trend between 2000 and the present. The TDS ground water concentrations for July 2011 are shown on Figure 4-2.

During vanadium plant operation, increases in TDS concentrations between 1993 and 1995 are attributed to the diverted discharge of the S-X stream into the scrubber pond instead of discharging to the S-X pond. During 1997, the scrubber pond liquid was pumped to the calcine pond in preparation of the scheduled remedial action for this facility. Incidental residual liquid in the scrubber pond was released from the pond near the location of well KM-3 during the stabilization of the scrubber pond solids. As a result, well KM-3 TDS concentrations spiked during 1997 from the effects of the residual liquid ponding at the surface in the near vicinity of the well. TDS concentrations in well

KM-3 have been decreasing since November 1997 following pond closure and reclamation.

Shallow wells near the former scrubber pond demonstrated larger variability in TDS concentrations between sampling events prior to pond closure. All wells continue to indicate overall decreasing trends, although concentrations spiked in May 2006 and decreased to the present range of concentration. TDS ground water concentrations in well KM-3 appear to show greater seasonal variability between 2000 and the present, compared with other shallow wells in this area. Seasonal increasing/decreasing trends may account for some of the variability between rounds. Intermediate depth well KM-11 demonstrated comparatively little variability.

Wells KM-5 near the historic scrubber pond and wells KM-9, KM-12, and KM-13 located near the west side of the facility or near the reclaimed S-X pond indicate a general TDS concentration decrease with time, and smaller overall decreases following 2000 as concentrations approached background. Concentrations of TDS in these wells have remained relatively range-bound since 2007. A spike in concentration is noted in 2006, with a smaller spike in 2011. Well KM-6 indicated slightly increasing concentrations through 1999, followed by a decreasing TDS trend through 2002, and a flattening of the trend between 2001 and the present. A spike in concentration is noted in the spring of 2006. Deep well KM-19 is near background concentration with respect to TDS. Well KM-8 indicates substantial variability with time, and suggests an overall decreasing trend between 1995 and 2005. TDS is variable in well KM-8 ground water after 2005, but TDS has a range-bound or slightly increasing trend between 2005 and 2011. Seasonal increasing/decreasing trends account for some of the variability between rounds.

Chloride

Chloride concentrations have decreased since the RI to the present levels noted on Figure 4-3. Chloride concentration trends in ground water for wells located near the

former pond facilities are contained in Appendix A. Trend graphs in Appendix A show that ground water in the vicinity of the reclaimed scrubber pond increased in chloride concentration through 1995 as a result of S-X stream discharges to this location. Currently, chloride concentrations are substantially greater near the scrubber pond and in well KM-8 near the former S-X pond. Shallow wells near the scrubber pond display variable chloride concentrations through 1997 between sampling events as the result of unlined pond operations. Intermediate depth well KM-11 is less affected by pond operational changes and indicates a more even (smoother) chloride trend with time. All wells monitoring ground water in this area demonstrate decreases in chloride concentrations between November 1997 and the present. The decreasing chloride trend in KM-2 slowed considerably after 2003, but chloride continues to decrease to the present at nearly all locations. Chloride concentration trends are nearly identical to TDS trends.

Wells located near the west side of the facility or near the former reclaimed S-X pond indicate chloride concentration decreases with time, with a general flattening of the trends between 2001 and the present. Well KM-6 chloride concentrations are also decreasing, but remain elevated above other wells in this area. A number of wells demonstrated an increase in concentration during the spring of 2006. Well KM-8 chloride concentrations show seasonal variability with larger concentrations in the fall, but generally decreasing concentrations through 2000, followed by a lack of seasonality in the data through 2004. Concentrations of chloride suggest a variably seasonal but range-bound chloride trend in well KM-8 between 2005 and 2012.

Sulfate

The July 2011 distribution of sulfate in ground water on site is shown on Figure 4-5. Sulfate concentration trends for wells located near the former pond facilities are contained in Appendix A. Sulfate trends in ground water near the reclaimed scrubber pond exhibit decreasing concentration trends that are comparable to chloride. An increase is noted in sulfate concentrations through 1996 as a result of S-X stream

discharges to this location. Sulfate concentration increases in well KM-3 in 1997 resulted from incidental residual liquid in the scrubber pond that was released from the pond during remediation and reclamation activities. As the direct result, concentrations of sulfate in well KM-3 spiked during 1997. KM-3 sulfate concentrations have decreased steadily since that time. Sulfate concentrations in wells KM-2 and KM-11 have been steadily decreasing between 1999 and the present. Sulfate concentrations in well KM-4 indicate decreasing concentration trends since 1997. Well KM-11 was less affected by plant operations, and shows an even (smoother) trend with time and a longer duration of peak sulfate concentrations. Sulfate concentration decreases near the scrubber pond have slowed between 2007 and the present.

Wells KM-5, KM-9, KM-12, and KM-13 sited near the west side of the facility or near the former S-X pond demonstrate sulfate concentration decreases over time with a flattening of the trend after 2000. Well KM-19 sulfate concentrations decreased to near background concentrations in 1998. Well KM-6 indicated little change with time through 2000, and then began to decrease though the present level, with a small spike noted in the spring of 2006. Sulfate concentration decreases near the S-X pond have slowed between 2007 and the present. Well KM-8 sulfate concentrations show similarities to chloride and TDS trends. Well KM-8 sulfate continued to indicate decreasing trends between 1995 and 2005. Concentrations are noted to be seasonal but relatively range-bound since 2005. Less seasonal variability in concentration is noted between 1999 and 2004, with more variability noted between 2004 and the present. Increased concentrations were noted in the fall during periods of lower water level elevations in this well prior to 2005. Since 2005, larger sulfate concentrations in well KM-8 typically occur during the spring sampling round.

Nitrate plus Nitrite

Nitrate plus nitrite concentration trends for wells located near the former pond facilities are contained in Appendix A. Wells KM-3 and KM-11 located near the reclaimed scrubber pond have relatively small nitrate plus nitrite ground water concentrations and

trends, and a relatively flat trend since LSE was implemented. Well KM-2 initially shows relatively larger nitrate plus nitrite ground water concentrations, with declining concentrations between 1999 and 2003, followed by a flattened trend with a spike in concentration occurring in 2006. Following LSE, a decreasing nitrate trend was noted in well KM-4. However, well KM-4 nitrate plus nitrite concentrations indicated an increasing concentration trend beginning in the fall of 2001 through the present, with significant spikes in concentration occurring 2005 to 2006, in 2009 and in 2011. Current nitrate plus nitrite ground water concentrations in well KM-4 are comparable to concentrations noted during the period when the scrubber pond and calcine ponds were operational.

Shallow wells near the west side of the facility or near the former S-X pond indicated a spike in nitrate plus nitrite concentration between 1993 and 1994 and variable concentrations with time during plant operation. Most wells show decreasing nitrate plus nitrite concentration between 1997 through May 2000. However, since 2001, a number of these wells show increasing concentration trends, with spikes in 2006, 2009 and 2011. Concentrations in well KM-6 suggest a steadily increasing trend between 2001 to the present, with a notable spike in 2006. Nitrate plus nitrite ground water concentrations in well KM-7 have been increasing since 2001 and are the most variable of this group of wells. Wells KM-13 and KM-9 also suggest slightly increasing nitrate concentration since 2004. Deeper wells KM-12 and KM-19 indicate little change with time. Well KM-8 concentrations spiked in 1994 and 1997, and decreased through 2001 following LSE. After 2001, a significantly increasing nitrate plus nitrite concentration trend is noted in KM-8 between 2001 and 2011, with a spike in 2009. The 2011 KM-8 nitrate plus nitrite concentration range is larger than concentrations noted during pond operations.

5.2.2 Metals Concentration Trends

Graphs of metal concentrations versus time include the group of metals identified by EPA as COC. COC metals versus time are presented in Appendix A and described in the following sections.

Arsenic

The arsenic risk based concentration (RBC) is 10 ug/l. This concentration value is based on the Federal MCL for drinking water. The results from July 2011 indicate that wells KM-2, KM-3 and KM-8 exceed the drinking water standard for arsenic, as shown on Figure 4-6.

Arsenic versus time plots presented in Appendix A indicate that wells located near the former scrubber pond denote ground water arsenic concentrations that are just below the RBC (10 ug/l). Well KM-3 demonstrates a slight increase in arsenic through 1997, primarily during the time-period that the S-X stream was diverted to the scrubber pond. Well KM-2 spiked in 1994 and has decreased since that time. Well KM-4 spiked in 1994 and again during 1997. Concentration spikes may have been related to discharge of the S-X stream to the scrubber pond. Arsenic concentrations have generally been decreasing near the former scrubber pond since LSE and reclamation in 1997, with a flattening of the trend since 1999.

Wells near the west side of the facility or near the former S-X pond indicate an arsenic concentration decrease with time through 1995. Sample results since October 2007 indicate that the 5 ug/l detection limit did not result in an increased number of wells exceeding the arsenic RBC. Arsenic concentrations in 2011 are smaller than those levels noted in 1998 for these wells.

Well KM-8 indicated an increasing trend following May 1995 when the pond was taken out of service, with a peak concentration occurring during 2002. The cause for the

increase in arsenic concentrations since closure of the S-X pond is unknown. Concentrations of arsenic decreased between 2002 and May 2006. Concentrations increased again between 2006 and 2008, but have been decreasing between 2008 and 2011.

Manganese

Ground water manganese concentration trends in wells located near the former pond facilities are contained in Appendix A. Wells located near the former scrubber pond show variable manganese concentrations throughout operation and then small decreases to the present. Increases in the concentrations of manganese during earlier time periods are attributed to S-X stream discharge into the scrubber pond. Wells KM-3 and KM-4 show significant variability between sample rounds through 1997. Manganese concentrations in well KM-4 ground water spiked during 1994 and decreased through the present. Manganese concentrations in well KM-3 spiked during 1997, decreased with time through 2000, then demonstrated a steady increasing trend to the present. Well KM-3 is the only well in this group near the scrubber pond that currently exceeds the RBC for manganese.

Wells near the west side of the facility or near the former S-X pond indicated a decrease in manganese with time between 1995 and 2000. Trends for manganese have flattened from 2000 to the present. Wells KM-6 and KM-7 indicate considerable manganese concentration variability with time that suggests seasonal trends, although this was less notable between 2002 and 2004. KM-6 indicated a relatively range-bound trend between 2004 the present, with spiking manganese concentrations in 2006, 2009 and 2011. Deep well KM-19 ground water is at background concentration levels.

Manganese concentrations in well KM-8 continue to exceed the RBC. During plant operation, the well KM-8 manganese trend showed decreasing concentration through 1994, followed by increasing concentrations through 1997. Concentrations of manganese have fluctuated, but generally began to decrease several years following

LSE and reclamation efforts in 1997. However, manganese concentrations in well KM-8 have been rising between 2004 and 2010, with a large drop in concentration in October 2010. Larger and increasing seasonal variability is noted between 2004 and 2011. Concentrations of manganese are currently within the range noted during pond operation.

Molybdenum

Ground water molybdenum concentration trends in wells located near the former pond facilities are contained in Appendix A. Molybdenum trends with time are comparable to sulfate trends.

Wells located near the former scrubber pond show decreasing molybdenum concentrations with time following LSE and reclamation through 2000. Following 2000, wells near the scrubber pond generally indicate decreasing molybdenum concentrations following 2000 to the present, although at a slower rate of decrease. Molybdenum concentrations in well KM-3 spiked in 1997 during the remediation and stabilization of the scrubber pond solids. Well KM-3 molybdenum concentrations increased between 2000 and 2003 then declined to the present levels. Seasonal concentration peaks are noted during the spring sampling rounds.

Wells KM-5, KM-9, KM-12, KM-13, and KM-19 located near the west side of the facility or near the reclaimed S-X pond indicated a concentration decrease with time through 2000, with much smaller decreasing trends noted between 2000 and the present. Concentration trends have essentially flattened since 2007. Well KM-6 indicates an overall decreasing molybdenum trend through 2003, with a range-bound trend between 2003 and 2010. Molybdenum spikes occur in 2006, 2009 and 2011. Larger molybdenum concentrations are noted during periods of higher water level elevation (spring sampling) in this well.

Molybdenum concentrations in well KM-8 peaked during late 1994. Well KM-8 indicates substantial concentration variability with time similar to the common ion trends and an overall decreasing trend with time following LSE and reclamation events through 2005. Molybdenum concentrations in KM-8 bottomed out in 2005. Since 2005, concentrations of molybdenum appear seasonal but range-bound at concentrations that are two (2) orders of magnitude greater the RBC.

Vanadium

Vanadium ground water concentration trends in wells located near the former pond facilities are included in Appendix A. Shallow wells located near the reclaimed scrubber pond indicate decreasing vanadium concentrations for most wells with time following LSE in 1997, but all wells indicate vanadium concentrations that are essentially range-bound since 2005.

Well KM-11 ground water vanadium concentrations are an order of magnitude below the RBC, and demonstrate little change since 1997. Well KM-3 trend indicates a flattening of the vanadium concentration between May 1998 and May 2001, and a steady trend in concentration of vanadium following capping of the calcine. Concentrations in well KM-3 have been seasonal but have not substantially decreased since 2005. Well KM-4 vanadium concentrations increased substantially through 1997 and decreased with time through early 2000. Concentrations of vanadium in ground water from well KM-4 increased between 2004 and 2008 with a large spike in concentration in 2006, and a decreasing trend after 2008. Well KM-2 vanadium concentrations increased through 1996 as the result of the S-X discharge to the scrubber pond, and decreased substantially in 1997 when the pond was reclaimed and the calcine pond dried. The trend for vanadium concentrations in well KM-2 ground water have been within a narrow range since 2005.

Wells KM-5 which is located near an historic scrubber pond and wells KM-6, KM-7, KM-9, KM-12, KM-13, and KM-19 located near the west side of the plant facility and near

the reclaimed S-X pond indicate that vanadium concentrations decreased more quickly with time prior to 2001. Wells KM-5, KM-9, KM-12, KM-13, and KM-19 continue to decline in concentration to the present at a slower rate since 2001. Wells KM-6 and KM-7 declined in concentration through 2004; however concentrations of vanadium in KM-6 and KM-7 have generally been flat or have increased since 2004. Wells KM-5, KM-6 and KM-7 ground water vanadium concentrations spiked in 2006, 2009 and in 2011.

Well KM-8 vanadium concentrations began to decrease in KM-8 beginning in 1992 (during plant operations) and continued to decrease following LSE in 1997. In May 1998, vanadium concentrations began to increase in well KM-8 with an increasing trend through 2004. Vanadium concentrations in well KM-8 ground water have been generally decreasing since 2005, but concentrations are highly variable.

5.2.3 Organics

Total Petroleum Hydrocarbons

KM-8 is the only POC well routinely sampled for TPH. TPH concentrations with time for well KM-8 are contained in Appendix A. Concentrations of TPH decreased with time in well KM-8 to less than detection in 1999. During 2000 and 2001, TPH ground water concentrations increased above historic ranges. Concentrations have decreased since 2000 to current levels of about 1.9 mg/l. The TPH ground water concentration trend in this well indicates a substantial decrease since 2000 with relatively steady concentrations demonstrating seasonal trends since 2005.

Tributyl Phosphate

KM-8 is the only POC well routinely sampled for TBP. Well KM-8 TBP concentrations with time are charted in Appendix A. Concentrations of TBP decreased through 2005 in well KM-8. Concentrations appear seasonal, with larger concentrations generally noted

in the spring sampling events. Concentrations have been within the same seasonal range since 2004, with spikes in 2008 and 2011.

5.2.4 Conclusions of On-Site Well Concentration Trends

Conclusions drawn from the review of on-site well concentration trends include:

- Nearly all on-site wells continue to exceed the RBC for molybdenum and vanadium.
- Molybdenum and vanadium has flattened or become range-bound for most of the on-site wells for the past five (5) to seven (7) years.
- Nitrate concentrations began to increase at many of the on-site locations after 2001. The location source for this nitrate is not well-understood.
- Some concentration spikes have been observed for nitrate, molybdenum and vanadium since remedy completion. This occurrence is notable in wells located along the southern boundary of the plant facility. Spikes are most notable in 2006, 2009 and 2011..
- Ground water in well KM-8 trends somewhat differently from the other site wells. Vanadium concentration increased three-fold following remedy completion through 2004. Vanadium concentrations in well KM-8 have fallen since 2004 to current levels that are within in the range of vanadium noted in ground water during plant operation.
- Concentrations of common ions generally decreased through 2011 in almost all POC wells following LSE and surface reclamation with larger concentrations in areas near or immediately downgradient of the former S-X pond and scrubber ponds.
- Concentrations of manganese declined following LSE to less than the RBC in all on-site wells with the exception of KM-3 and KM-8 that currently demonstrate increasing concentration trends over time.
- Several shallow wells indicate seasonal variability in concentration, with larger concentrations occurring in the spring. For some wells, including KM-6 and KM-8, this seasonal trend was less noteworthy for the period between 2002 and 2006.
- TPH continues to slightly exceed the RBC in KM-8, although trends indicate a relatively flat but seasonal trend that is currently above the RBC.

- TBP is currently detected in KM-8 within the same concentration range noted for the past ten (10) years. TBP is seasonal and occasionally has not been reported.
- Arsenic remains above the arsenic MCL in well KM-8 near the covered S-X pond, but arsenic concentrations have been generally decreasing since 2002. Arsenic also exceeds the MCL in wells KM-2 and KM-3.

5.3 Off-Site Well Concentration Trends

The following sections provide a discussion of concentration trends with time for the off-site wells (Trust wells located beyond the POC), located to the south of the plant facility on the property previously owned by Larry Hopkins, but purchased by Kerr-McGee in 2004 and transferred to the Trust in February 2011. Off-site wells that are now on Trust property include wells KM-15, KM-16, KM-17, and intermediate depth well KM-18. Changes in concentration with time are generally smaller in the off-site wells as a function of their greater distance from the site and pond areas that impacted ground water quality.

In general, concentrations and concentration trends observed in paired shallow and intermediate wells KM-15 and KM-18 are similar for some of the monitored parameters as the result of the downward vertical gradient noted between water levels in these wells. Concentrations decreased steadily in these wells since the time of the remediation of the MAP ponds in 1993. Wells KM-15 and KM-18 appear to be more directly affected by activities on the west side of the plant facility. Well KM-16 indicates seasonal fluctuations and spikes in concentrations for a several constituents, in particular during 2006 and 2011. Well KM-16 also demonstrates similar concentration trends to on-site well KM-6. Well KM-17 has been impacted by operations on the east side of the site that occurred in the vicinity of the former scrubber pond. Well KM-17 has relatively large concentrations of common ions and molybdenum, but appears minimally impacted by arsenic, manganese, and vanadium.

5.3.1 Common Ions and General Indicators

Based on a review of concentrations versus time for these parameters, the following general observations are described below. Graphs of concentrations versus time that are the basis for identifying the trends are contained in Appendix A.

TDS

Paired wells KM-15 and KM-18 have similar TDS concentrations, and show an overall decrease in concentration with time through 2011, with a flattening of the trend after 2005. Well KM-16 shows a decreasing trend with time following LSE, but also demonstrated a spike in concentration in 2006 and in 2011. Seasonal trends account for some of the variability between rounds. Increased concentrations in well KM-16 occurred during periods of increased moisture and higher water level elevation.

Well KM-17 had the largest of the off-site well TDS concentrations through 2004. Concentrations in this well result from historic operations at the scrubber pond. Concentrations in KM-17 are now comparable with the other off-site wells

Chloride

Wells KM-15 and KM-18 indicate matching concentrations, and show an overall decrease with time, beginning prior to LSE. The trend flattened between 2003 and 2010. Concentrations of chloride in wells KM-16 and KM-17 lag wells KM-15 and KM-18 and were directly affected by LSE, since wells KM-15 and KM-18 indicated an earlier decrease in chloride. KM-16 indicated a larger decrease following 1999. Well KM-17 chloride concentrations were the largest identified in the off-site wells through 2005. Concentrations are currently similar and have been range-bound since 2007.

Sulfate

Ground water in wells KM-15 and KM-18 indicate nearly identical sulfate concentrations, and show an overall decrease with time since initial sampling in 1992. This trend flattened after 2000. Well KM-17 sulfate concentration trends decreased following LSE and scrubber pond reclamation efforts in 1997. Sulfate concentrations have been range-bound in all of the off-site wells for the past five (5) years.

Nitrate plus Nitrite

Ground water concentrations of nitrite plus nitrate decreased in the off-site wells following LSE through around 2001. After 2001, wells KM-15, KM-16 and KM-18 demonstrated large seasonal changes with larger concentrations noted in the spring sampling events. Nitrate concentrations have been rising since 2001 and are currently 2 to 3 times the levels noted in 2001. Well KM-17 has the smallest nitrite plus nitrate ground water concentrations of all of the off-site wells and also demonstrates the smallest variability with time with an overall decreasing trend.

5.3.2 Off-Site Metal Concentration Trends

Graphs of metal concentrations versus time include the group of metals identified by EPA as COC. COC metals versus time are presented in Appendix A and described in the following sections.

Arsenic

All off-site wells are well below the arsenic method detection limit of 5 ug/l and the RBC of 10 ug/l, as shown on Figure 4-6.

Manganese

Off-site wells are below the RBC for manganese, as shown on Figure 4-7. Concentrations of manganese in well KM-15, KM-16, and KM-18 decreased with time from initial concentrations that were greater than the RBC. Well KM-15 concentrations are approaching concentrations noted in deeper well KM-18. Well KM-17 ground water manganese concentrations remain low, near the detection limit. Well KM-16 indicates an overall decreasing trend with time and seasonal trends between rounds. Increased concentrations occur during spring sampling rounds. Decreases in manganese concentrations in KM-16 show a lag time behind the other off-site wells.

Molybdenum

All off-site wells currently exceed the molybdenum RBC of 180 ug/l. Distributions of molybdenum in the ground water are shown on Figure 4-8. Ground water molybdenum concentrations in wells KM-15 and KM-18 are very similar, and both peaked during pond operation and then began to decline after 1993. Both wells have similar concentration trends and both indicate significant concentration decreases with time through 2000. The decreasing trend slowed after 2000 and have essentially been range-bound for the past five (5) year. Spikes are noted in 2006 and again in 2011. Concentrations of molybdenum in well KM-16 decreased following remedy completion through 2004 with notable seasonality through 2001. Increased concentrations occurred in the spring during periods of higher water level elevation. KM-16 molybdenum concentrations spiked in the spring of 2006 and again in 2011. However, concentrations of molybdenum have been range-bound in KM-16 since 2004. KM-17 molybdenum concentrations increased between 1998 and 2003 then declined slightly to the current concentrations that continue to remain above the RBC but within the molybdenum ranges noted in the ground water from wells KM-15 and KM-18. Well KM-17 does not define the eastern extent of ground water exceeding the RBC.

Vanadium

Off-site wells exceed the 260 ug/l RBC for vanadium with the exception of well KM-17, which has relatively unchanged concentrations since November 1997. Concentrations of vanadium in wells KM-15 and KM-18 peaked prior to 1993 during pond operations and began to decline after diversion of the S-X stream to the scrubber pond and elimination of the MAP ponds. Both wells KM-15 and KM-18 have parallel decreasing concentration trends, with well KM-18 having a consistently lower concentration. Both wells indicate decreasing concentration trends through 2000, with a flattening of the trend after 2000. Concentrations of vanadium appear range-bound since 2008 at levels above the RBC. Well KM-16 has the largest ground water vanadium concentration of all off-site wells. Well KM-16 vanadium concentrations spiked in 2006 and again in 2011. Concentrations of vanadium in well KM-16 appear range-bound for the past four (4) years.

5.3.3 Organics

Organics are no longer sampled in the off-site wells. TPH was last sampled off-site in November 1996. Concentrations of TPH remained relatively unchanged with time. Concentrations of TPH during 1996 were reported at the detection limit. TBP concentrations increased through May 1994 in the off-site wells; and then decreased to less than the RBC in October 1995. TBP in well KM-16 was not detected after May 1993.

5.3.4 Conclusions of Off-Site Well Concentration Trends

Conclusions drawn from the review of off-site well concentration trends include:

- Off-site wells exceed the RBC for molybdenum and vanadium (except KM-17 that is less than the RBC for vanadium), but are below the RBC for arsenic, manganese, and assumed to be below the RBC for organics. Concentrations decreased with time following LSE, although a concentration spike was noted in some wells in 2006 and again in 2011.

- Concentrations of common ions and TDS continue to generally decrease with time following LSE and reclamation. Concentration decreases of common ions flattened in KM-16 with a number of parameters spiking in concentration in 2006 and in 2011.
- Nitrate plus nitrite concentrations suggest strongly seasonal trends with a rising trend in nitrate noted in wells KM-15, KM-16 and KM-18 after 2001. Concentrations have at least doubled in three of the wells since 2001

5.4 Off-Site Surface Water Quality Concentration Trends

Tronox routinely monitored surface water quality at four spring locations on a semiannual basis. Springs that are sampled include Finch Spring, Big Spring, and Upper and Lower Ledger Springs. Spring samples are analyzed for general indicator parameters, common ions, and metals. Concentrations versus time graphs for these springs are presented in Appendix A.

Finch Spring originates from the base of the Finch Spring Fault scarp, at a location that is approximately 4000 feet to the south of the former Tronox facility. Finch Spring has been routinely sampled since 1991. Flow from this spring discharges to a pond that flows to Kelly Park. Discharge from Finch Spring is typically less than 50 gpm.

Big Spring was initially sampled by Kerr-McGee in 1993. This spring is impacted by the Trust site and the Monsanto facility. Flow from this spring is considerably greater than Finch Spring discharge, although Big Spring flow was smaller between 2001 and 2004 due to several years of below normal precipitation. Discharge from Big Spring was approximately 18.2 cubic feet per second (cfs) in July 2011.

Big Spring is the most distant spring relative to the site, located approximately 2.8 miles south of the facility and south of the town of Soda Springs. Big Spring is located at the most downgradient discharge point in the valley, at the fish hatchery adjacent to the Bear River. Big Spring emerges from alluvium at the south end of the valley floor and flows into Hatchery Creek and then into the Bear River.

Upper and Lower Ledger Spring discharge at a location approximately 3,300 feet to the southeast of Finch Spring. Both springs issue from the basalt aquifer. During June 2000, EPA requested that Kerr-McGee resume routine sampling of Upper and Lower Ledger Springs. These springs were first sampled by Kerr-McGee in 1991. These springs are one source of drinking water for the City of Soda Springs. Sample results with time are presented for Upper and Lower Ledger Springs in Appendix A. Concentrations of COC metals are typically less than detection in Upper and Lower Ledger Springs, although molybdenum and vanadium are occasionally detected at concentrations near the detection limit.

5.4.1 Common Ions and General Indicators

TDS

TDS concentrations at Finch Spring increased through October 1994 as the result of pond operation at the site and changes in the discharge of the S-X stream. TDS concentrations decreased steadily between 1995 and 2002, with a smaller seasonally-affected decreasing trend between 2002 and 2011.

Small seasonal trends are noted in the Big Spring TDS data. Concentrations of TDS at Big Spring decreased consistently since 1996 to current levels of under 600 mg/l that are comparable to, but slightly greater than Finch Spring. TDS concentrations decreased steadily in Big Spring between 1995 and 2001. Between 2001 and 2011, the decreasing TDS trend flattened substantially when compared with the rate prior to 2001.

TDS concentrations in Ledger Springs were 480 mg/l in July 2011. Lower Ledger generally has indicated slightly larger concentration than Upper Ledger in past sampling events. TDS concentrations at the Ledger Springs are less than the concentrations at Big and Finch Spring, and are more representative of background water quality

concentrations. Concentrations appear seasonal, and trends suggest seasonal but generally decreasing TDS concentrations since 2000.

Chloride

Chloride is a conservative tracer because transport in ground water is generally through the hydrodynamic process, traveling essentially at the same rate as ground water flow. Therefore, changes in chloride concentrations at Finch Spring reflect process and remedial changes at the plant.

Concentrations of chloride at Finch Spring increased through October 1994, peaked again in late 1996, and then decreased in concentration through 2011 below 1991 levels. Concentration decreases slowed between 1999 and 2002, but continued a slower decrease in concentration through the present.

Chloride concentrations decreased in Big Spring after 1996. The decreasing chloride trend continued, but flattened between 2001 and 2011. The chloride concentrations at Ledger Springs are an order of magnitude less than chloride concentrations at Big and Finch Springs and represent background. Chloride concentrations at both Ledger springs are about 6 mg/l.

Sulfate

Sulfate trends at Finch Spring are remarkably similar to the chloride trends. Sulfate peaked in October 1994 and 1996, and then decreased to the present concentration levels. Changes in Finch Spring sulfate concentrations are related to former S-X stream discharges to the scrubber pond. Concentrations of sulfate at Finch Spring decreased in 2010 to below the range of 1991 concentrations. The sulfate trend at Finch Spring is relatively flat since 2005.

Sulfate concentrations at Big Spring are typically greater than the concentration at Finch Spring. Big Spring also indicates a steady decrease with time between 1994 and 2011. The Ledger Springs sulfate concentrations are also smaller than sulfate concentrations

at Big and Finch Springs, and are approximately 32 mg/l. Seasonal trends are noted, but no long-term trends are noted for sulfate in Ledger Springs.

Nitrate plus Nitrite

Nitrate plus nitrite concentrations are similar at Finch and Big Springs locations, with slightly larger concentration at Big Springs. Both locations suggest slight seasonal trends in the data, with larger concentrations occurring in the fall season. Both locations indicate generally decreasing concentration trends with time through 2001 and a range-bound but seasonal trend between 2001 and 2011. Ledger Spring nitrate plus nitrite concentrations peaked in 2011 but are an order of magnitude lower than the primary drinking water MCL and the nitrate plus nitrite concentrations at Big and Finch Springs. However, nitrate concentrations increased significantly in both of the Ledger Springs in 2011, and data suggest an increasing nitrate trend at these springs over time, with spikes occurring in 2006, 2009 and 2011.

5.4.2 Metals Concentration Trends

Graphs of metals versus time are presented in Appendix A and described in the following sections.

Arsenic

Arsenic concentrations are less than the RBC and reporting limit at all spring surface water locations during 2011.

Manganese

Concentrations of manganese are less than the RBC and generally less than, or near the reporting limit at Finch Spring. Concentrations of manganese are less than 1 ug/l at Upper and Lower Ledger spring locations in 2011.

Molybdenum

Historic increases and decreases in molybdenum concentrations for Finch Spring were noted during the RI to be related to changes in the discharge locations of the S-X stream. Concentrations of molybdenum at Finch Spring indicate decreasing trends through 1996. After 1996, the molybdenum concentration then increased sharply and peaked in July 1997. Concentrations of molybdenum at Finch Spring decreased steadily between 1997 and 2009 to less than the RBC.

Molybdenum concentrations increased at Big Spring through 1997 then decreased through 2011. The molybdenum concentration fell below the RBC in 2009.

Molybdenum was estimated less than detection at the Ledger Springs in 2011. Molybdenum has been detected infrequently at levels near or below the reporting limit since 2000.

Vanadium

Finch Spring demonstrates an overall increasing trend in vanadium since monitoring began. Vanadium concentrations increased at Finch Spring through 2001. Concentrations of vanadium peaked in Finch Spring during 2001 at a concentration of 92 ug/l and then demonstrated an overall decreasing trend to 52 ug/l in 2011. Increases in vanadium concentrations at Finch Spring are believed to be the result of operational S-X stream discharges to the scrubber pond. Vanadium was detected at a small concentration of 4.3 ug/l in Big Spring in July 2011. Vanadium concentrations ranged from 1.1 to 1.6 ug/l at the Ledger Springs in October 2011.

6.0 PROJECTED CONCENTRATION DECAY TRENDS

6.1 General

COC concentration trends with time and projected trends for these wells are presented in Appendix B. Projected trends are based on the post-LSE monitoring period data. The projected period into the future varies between wells in order to demonstrate the approximate time when the COC is projected to fall below the RBC. The purpose of the trend evaluation is to assess the likelihood of the remedy to achieve the cleanup goals. To accomplish this, ground and surface water COC data (specifically molybdenum and vanadium and manganese for KM-3 and KM-8) were evaluated for the period following cessation of the last of the uncontrolled waste stream discharges (October 1997) to estimate the relative change in ground water COC concentrations that resulted from LSE. The calcine was not capped until approximately four (4) years after the ponds were taken out of service, so effects of the infiltration and ponding in the calcine area affected some of the early time COC concentration data for some of the wells, including wells KM-2, KM-3 and KM-4. Methods used to evaluate the data include: 1) regression analyses that are discussed in this section with the regression curves, and; 2) regression equations and coefficients that are presented in Appendix B.

Existing data collected as part of the monitoring program were evaluated using regression analysis. Two data sets were evaluated by this method. The first data set included vanadium and molybdenum data from November 1997 to October 2011, the period following the implementation of the remedial actions. This truncation was prepared to focus the evaluation on the trends following the implementation of the remedial actions. The second evaluated set of data includes vanadium and molybdenum data results from a shorter period of time (May 2004 through October 2011). These data were evaluated in conjunction with the November 1997 through October 2011 data set to assess whether the more recent data set that includes spikes and range-bound data demonstrate trends that are notably different from the overall LSE time period. These evaluations were done for each point of compliance and off-

site monitor well that currently exceeds the RBC. The purpose of this evaluation was to estimate when cleanup performance standards can reasonably be expected to be met for ground water.

6.2 Results of Regression Analysis

An analysis using the November 1997 through October 2011 and the May 2004 through October 2011 data sets provide an estimate when these concentrations may potentially fall below their respective RBC for molybdenum and vanadium. TBP and TPH data from wells other than KM-8 are not available, and therefore are not included in this analysis.

Arsenic was detected during the RI in the limestone settling ponds at a concentration of 190 ug/l with much smaller concentrations in the MAP (14.7 ug/l) and scrubber pond (8 ug/l). Arsenic is not evaluated in the regression analysis because concentrations were less than detection in most wells between 1999 and 2007. Following 2007, the arsenic method detection limit was lowered to 5 ug/l and most of the wells are less than the RBC of 10 ug/l. There are no clear trends for arsenic in well KM-8 relative to pond elimination, or in the wells (KM-2, KM-3 and KM-4) surrounding the covered scrubber pond where arsenic concentrations are close to the RBC.

Manganese is evaluated for wells KM-3 and KM-8. Both wells KM-3 and KM-8 demonstrate increasing manganese concentrations in ground water with time. The remaining wells demonstrate that manganese concentrations in the ground water are less than the RBC.

Projected concentration decay trends are estimated where possible, using a regression trend curve fitted to the real-time monitoring data from ground water where the COC currently exceed the risk-based concentrations of manganese, molybdenum and vanadium. These COC were selected because most of the risk in ground water is driven by the occurrence of these metals. The time periods used to evaluate the projected COC trends included the period from November 1997 (the first round of

ground water collected from the monitoring points following LSE) through the October 2011 round and a shorter period, from May 2004 to the present.

Data analyzed to project future trends include ground water results obtained from wells KM-2, KM-3, KM-5, KM-6, KM-8, KM-9, KM-12 and KM-13 that are located on the vanadium plant site; and off-site wells KM-15, KM-16, KM-17 and KM-18 that are located south of the site. Plotted results of the regression analysis are presented in Appendix B.

Results of the predictions based on the 1997 to 2011 data are summarized in Table 6-1. Projections for COC based on the 2004 to 2011 data are summarized in Table 6-2. These tables show the most recent concentrations from each well (October 2011), the year that each COC is projected to fall below the RBC, the regression equation, the coefficient of determination (R^2) and correlation coefficient (R) for each of the evaluated cases. The larger the correlation coefficient (closest to 1.00), the stronger the correlation, or the strength of the relationship between variable data points. The coefficient of determination (R^2) is a measure of how well the regression line represents the data, and provides the proportion of the fluctuation in the data that is predictable from the previous data point. The larger the R^2 value, (closest to 1.00), the greater the certainty of the next projected concentration value.

Most of the wells, both on and off the industrial site and the springs demonstrate decreasing molybdenum and vanadium concentrations based on the data from the 14-year LSE evaluated period. However, as the result of spiking concentration trends for some of the wells in 2006, 2009 and 2011 in ground water downgradient of the former scrubber and S-X ponds, or based on flattened, range-bound trends noted over the past 4 to 6 years, the estimated time to reach the RBC cannot be reliably projected. The wells that appear somewhat uncertain to reach the RBC following LSE include wells KM-2 and KM-3 near the former scrubber pond, KM-5 near the MAP ponds and buried historic scrubber pond, and wells KM-6 and KM-8 that are south and downgradient of the limestone settling ponds and the covered S-X pond basin. Well KM-5 located near

the former historic scrubber and MAP ponds achieved molybdenum cleanup levels in 2008, but returned above the RBC in 2011. Hence, the small R^2 value, indicating the period of time required to achieve the RBC cannot be projected with certainty.

Analysis of 2004 to 2011 vanadium data from this group of wells shown in Table 6-2 indicates that the time to reach the RBC could be substantially longer than the estimated times from the 14-year data set. The data set also reflects a much smaller coefficient of determination for in nearly each well case, except well KM-12. This is due to the fact that the 2004 to 2011 data set, for the most part, contains data spikes, is range-bound, or exhibits a rate of decrease that is substantially slower than the period immediately following LSE. These data (2004 through 2011) that include spiked concentrations following wetter periods implicate COC mass loading to the aquifer in the absence of leaking pond sources.

6.2.1 Analytical Method

Existing ground water data were evaluated using a statistical forecast function for exponential decay. A forecast calculates or predicts a future value by using existing values. The predicted value is a y-value (future concentration of a COC in ground water) for a given future date. The known values are ground water data from the wells. A forecast statistically predicts future values based on a regression function of a range of known data or known x- and y-arrays. Regression analysis estimates the relationship between variables, so that a given variable can be projected from one or more other variables.

Data curves for the ground water concentrations shown in Appendix B were generated using an exponential function that describes decay of a substance and calculates the least squares fit through points by using the equation:

$$y = ce^{-kt}$$

where:

e is the base of the natural logarithm;

c is a constant at y_0 (initial concentration) at $t = 0$, and;

$-kt$ is a constant for the predicted time, with the minus sign representing decay of concentration with time.

A trend line, the equation for that trend line and the coefficient of determination are generated for the data set based on known x-values for the best-fit curve. The y intercept for the regression trendline is set at zero. This is appropriate, based on the assumed absence of manganese, molybdenum and vanadium concentrations in background ground water quality data.

6.2.2 Results of Trendline Analysis

Results of the trendline analysis are presented on the Figures in Appendix B. It is possible that future ground water concentration trends may differ from results generated using the two data sets, or that future trends may fall in between the projections based on each data set. The minimum range of each graph has been set at the respective RBC. Analysis of the forecast trends suggests the following from the November 1997 to October 2011 data set:

- Molybdenum concentrations will continue to decline in most wells in response to LSE and reclamation. However, wells downgradient of the former S-X and scrubber ponds will have molybdenum concentrations exceeding the RBC well into the future. Monitor wells that demonstrate greater uncertainty to reach the molybdenum RBC following LSE include wells KM-3 near the former scrubber pond, and wells KM-6 and KM-8 that are south and downgradient of the covered S-X pond basin and the site.
- Monitor wells that appear somewhat uncertain to reach the vanadium RBC following remedy completion include wells KM-2 and KM-3 near the former scrubber pond, well KM-5 near a historic scrubber pond and the MAP ponds, wells KM-6 and KM-8 near the former S-X waste stream, and possibly well KM-16 that located south and downgradient of the site.

- Molybdenum in wells KM-5 and KM-9 fell to the RBC in 2003 as predicted by use of these trendlines, but spikes occurred in 2006, 2009 and 2011 that exceeded the RBC.
- On-site wells and several off-site wells are forecast to exceed the vanadium RBC for a period of twenty years or greater following remedial actions completed in 1997. Based on current trends, wells KM-9 and KM-13 are the first wells expected to fall below the vanadium RBC. Monitor wells located south of the former S-X and scrubber pond will have vanadium concentrations exceeding the RBC far beyond 2020 based on current trends.
- Manganese is estimated to potentially exceed the RBC for more than 40 years following LSE in well KM-8, in part as the result of a rising manganese trend since 2004. The rising manganese trend in well KM-8 is not occurring in other wells monitoring the S-X pond area.
- Well KM-3 will exceed the manganese RBC for an uncertain period because a decreasing trend cannot be projected from the data. The rising manganese trend in well KM-3 is not occurring in other wells monitoring the covered scrubber pond area.

7.0 CONCLUSIONS

Kerr-McGee discontinued waste-water discharges to a number of unlined process ponds between 1995 and 1997. Ground water data indicate that remediation efforts of the ponds prior to and during 1997 resulted in notable ground water quality improvement at most of the on-site, point of compliance, and off-site well locations and off-site springs. Currently, a number of the wells demonstrate ground water COC concentration trends that have flattened or are range-bound at concentrations that are above the risk-based concentration. A few wells have ground water trends that indicate increasing COC concentrations since remediation was completed.

Projected future concentrations that are based on a data regression for the time period since the ponds were removed from service indicate that some of the COC will persist in the ground water for a considerable period of time, or that concentrations will not achieve clean-up levels. Analysis of the same data over a shorter period of time (2004 to 2011) results principally in greater uncertainty and an extended projected date that concentrations will fall below risk-based levels for most of the wells. Wells that indicate uncertainty in reasonably achieving clean up goals include wells near the former scrubber pond, wells that are interior to the site including wells KM-4 and KM-7 and wells that monitor ground water to the south and downgradient of the covered S-X pond basin and the site.

Based on a review of water quality results through October 2011, recent water quality trends, and predictions of future concentrations, the following conclusions are drawn.

On-site Water Quality Conclusions

- Vanadium and molybdenum continue to exceed the RBC at most of the on-site POC wells and non-POC wells.
- Concentrations of molybdenum and vanadium in ground water increased in 2011 at a number of on-site wells, including wells KM-5 and KM-9 that increased to above risk-based levels in for molybdenum in 2011.

- The largest continued on-site impacts to ground water occur immediately downgradient or south of the former scrubber and S-X pond basins. Projected time periods for concentrations in these wells to fall below the risk-based levels has a low level of certainty based on the fit of the data to the regression line. Evaluation of these data over a shorter time period results in greater uncertainty.
- Generally, concentrations of common ions and TDS have decreased with time in the on-site wells. This trend has flattened somewhat between 2000 and the present for a number of the on-site wells near the west side of the facility as these concentrations approach background.
- Increased or spiked concentrations at several wells between 2004 and 2006 and again noted in 2011 may be related to increased soil moisture residence time or the result of increased infiltration though unmitigated on-site sources. Seasonal concentration trends noted in some well locations, including KM-6 and KM-8 also appear to be correlated with changes in water levels which are correlated to changes in annual precipitation rates.
- A continued rising nitrate trend is noted at most well locations near the covered S-X pond and downgradient of the former plant site. Nitrate plus nitrite concentrations have increased seven times in well KM-8 between 2001 and 2011. A fivefold increase in nitrate plus nitrite is also noted in shallow well KM-4 southwest of the calcine cap.
- The site pH is neutral to slightly basic across the site and at off-site locations, with the lowest pH areas identified near the former S-X pond.
- Concentrations of TPH and TBP exceed the RBC in well KM-8 ground water. TPH indicates a decreasing ground water trend through 2005 with only seasonal changes noted to the present. TBP indicates an overall decreasing trend since LSE was implemented through 2004 with a seasonal fluctuation within this range to the present.
- Concentrations of arsenic in ground water are found above the RBC in well KM-8 near former S-X pond. Arsenic is identified just above the RBC near the former scrubber pond and at small concentration in shallow ground water in both on and off site wells not located near these sources.
- Manganese decreased with time in nearly all wells following LSE and the remedial actions completed in 1997. Manganese concentrations are found above the RBC in two wells monitoring the former S-X and scrubber ponds. Well KM-3 indicates an increasing manganese trend following implementation of LSE. Well KM-8 manganese concentrations are seasonal and have been increasing since 2004.
- On-site deep well KM-19 was below the RBC for all COC in 2011.

- The projected period of time for COC concentrations to fall below the risk-based level is substantially longer than previous ground water modeling estimates for LSE. This suggests that unmitigated on-site solid wastes remaining from former operations continue to contribute COC to the ground water.

Off-Site Ground and Surface Water Quality Conclusions

- Generally, common ions and TDS have decreased with time in the off-site wells.
- Concentration spikes in well KM-16 in 2006 and again in 2011 correspond with a rise in ground water levels and correlates with increased annual precipitation.
- Ground water concentrations of common ions and TDS decreased in well KM-17 since peaking in 1998. Molybdenum concentrations indicate a decreasing trend in well KM-17 but levels still exceed the risk-based concentrations. The eastern extent of molybdenum in ground water exceeding the risk based level remains undetermined. Vanadium concentrations in well KM-17 are less than the RBC.
- Vanadium and molybdenum concentrations in ground water continue to exceed the RBC in off-site wells KM-15, KM-16 and KM-18. Molybdenum concentrations in these wells spiked in 2011 similar to the spikes noted in 2006. Vanadium concentrations decreased in wells KM-15, KM-16 and KM-18, although vanadium concentrations appear to be range-bound at levels that are well above the risk-based level.
- Arsenic in the ground water is near the method detection limit and below RBC at all off-site well locations.
- Manganese continues to decrease at off-site well locations and is less than the RBC at all off-site locations.
- Finch and Big Spring fell below the RBC for molybdenum in 2009. Molybdenum trends at both locations have flattened between 2009 and the present.
- Vanadium concentrations in Finch Spring remain elevated but are less than the RBC. Vanadium concentrations at Finch Spring indicate a decreasing trend since 2001, but levels remain elevated. Vanadium concentrations in Big Spring remain in the 3 to 4 ug/l range.
- Water quality at Upper and Lower Ledger Springs (City of Soda Springs drinking water supply) does not indicate COC from former site operations based on 2011 water quality results. However, nitrate plus nitrite concentrations in both springs

have been increasing over time with the largest concentrations to date reported in 2011. Nitrate levels remain within drinking water MCL.

COC Trendline Projections

- Manganese concentrations are increasing in wells KM-3 and KM-8, therefore it is not possible to predict when these concentrations will fall below the risk-based concentration.
- In most cases, predicted future COC concentrations using data obtained following remedy implementation results in stronger correlation and a better data "fit" compared with the same analysis using the data set from 2004 to the present. The shorter data set evaluation suggests a weaker correlation and a longer time period to achieve clean up levels as vanadium and molybdenum concentrations have become range-bound over the past few years in a number of wells.
- Since implementation of the remedy, data indicate that molybdenum is projected to fall below the RBC in four on-site POC wells (KM-2, KM-5, KM-12 and KM-13) and three of the off-site monitoring wells (KM-15, KM-17 and KM-18) within the next fifteen years. Molybdenum concentrations will continue to exceed the RBC at the on-site wells monitoring the former S-X and scrubber ponds (KM-3, KM-6 and KM-8) for a considerably longer period (between 30 and 90 years from the present).
- The concentration of vanadium in the ground water is projected exceed the RBC in most on-site POC wells and off-site wells for a longer period of time than molybdenum. Wells KM-9, KM-12 and KM-13 are predicted to be near the vanadium RBC within the next 15 years. Vanadium ground water concentrations will continue to exceed the RBC at the shallow on-site wells monitoring the former S-X and scrubber ponds (KM-2, KM-3, KM-6 and KM-8) for considerably longer based on increased or flattening concentrations and concentration spikes noted during the past 7-year period. Vanadium correlation coefficients for wells KM-3 and KM-8 are relatively weak and make predictions of achieving risk-based levels difficult.
- As a result of overall larger concentrations and unclear trends for arsenic, manganese, molybdenum and vanadium, well KM-8 continues to lag other wells in concentration decreases. Therefore, KM-8 will take considerably longer to fall below the RBCs for arsenic, manganese, molybdenum and vanadium. Data projections suggest that it is possible that these ground water concentrations will not meet clean up goals unless further actions are taken at the former S-X pond location.

8.0 RECOMMENDATIONS

Ground and surface water monitoring will continue at the former Tronox facility on a semiannual basis to assess the effects of remedial changes made at the site as required in the ROD. Field data results should be evaluated when sampling occurs to assess current with preceding site conditions.

Parameters that fall below the RBC will be evaluated and reported to EPA when these occur. All sampling and analytical results should be reviewed semiannually in accordance with the protocols contained in SW846 and EPA laboratory data validation functional guidelines to assess the quality of the data results. Ground and surface water quality will be appended semiannually to the RD/RA database. Results of the data review will be transmitted to the Trust, EPA and IDEQ.

All ground water quality trends and predicted water quality should be evaluated in an annual report to assess the improvements to ground and surface water quality. Future annual reports should include evaluation of ground water monitoring data from the off-site Evergreen facility, in order to evaluate whether ground water flowing off the Trust property is controlled to prevent consumption at levels that exceed the RBC. This facility monitors ground water downgradient of the Tronox property on industrial property owned by the City of Soda Springs. Evaluation of Evergreen data in conjunction with Tronox ground and surface water data would provide an increased understanding of ground water flow paths downgradient of the former Tronox site. Unfortunately, this facility was not sampled during 2011, therefore off-site impacts downgradient from the Trust site cannot be compared with the 2011 data.

The following recommended changes to the monitoring plan can be made without reducing the information required to assess remedy performance. In general, wells with COC that show the largest variation in long-term trends and demonstrate seasonal variations are important to understanding the fate and transport of the COC relative to the remedy evaluation. These wells will continue to be monitored at least semi-annually

to document these long term and seasonal changes. Wells that show flatter trends that decline more slowly or are relatively flat also help with the understanding of remedy performance. Flat trends, particularly those with concentrations above established RBCs, provide valuable information related to the effectiveness of the remedial actions in achieving cleanup goals. However, because the concentrations in these wells rarely change, less frequent monitoring is prudent. Therefore, recommended changes for the long-term monitoring using the current network are shown in Table 8-1 and include:

- Continued semiannual monitoring for most POC wells that continue to show decreasing trends or seasonal fluctuating trends (wells KM-2, KM-3, KM-4, KM-6, KM-8, KM-9, KM-11, KM-12 and KM-13);
- Recommended annual monitoring (in the spring) for POC wells with flat trends and internal non- POC wells (wells KM-5 and KM-7);
- Well KM-19 has already achieved the clean-up goals and could be monitored less frequently (i.e. annually in the spring round);
- Semiannual monitoring of off-site wells and springs should continue as the result of noted significant seasonal fluctuations and the importance of these well sites for defining areas of off-site migration of COC;

For future sampling events, POC wells that indicate ground water concentrations below the RBC could have monitoring frequency reduced to annual monitoring (based on mutual agreement with EPA) to ensure concentrations do not climb above the RBC.

Additional investigations to assess data gaps in the current monitoring network are warranted and could be performed in a phased approach according to an EPA approved work plan. Data from wells KM-15 and KM-18 indicate their piezometric heads are influenced by drawdown induced by the Monsanto production wells. Water quality data at off-site wells KM-15 and KM-18 indicate that COC are mixing vertically and currently exceed the RBC in the shallow and intermediate depth basalt aquifer at this location based on water level observations and water quality trends. The degree to which this mixed ground water is captured by the Monsanto production wells is unknown. Some of the mixed deeper ground water may follow regional ground water

flow gradients, assumed to be to the south from this area. No deeper well data is available to the south of Monsanto well TW-11 on the southeast corner of the Monsanto site. Therefore, in order to assess deep water quality and potential pathways and exposures off of the former Tronox site, a deep well should be sited on the City of Soda Springs property, preferably downgradient of the Monsanto well capture zone. Ideally, a deep well would accompany a shallow well to assess vertical gradients and be sited within the most contaminated shallow ground water. This location would ideally be placed no further south than the Evergreen facility. These investigations were identified in the monitor well network evaluation report (GET, 2010) and should include:

- Evaluation of potential receptors along the pathway between the site and Big Spring through a water rights and well database study to obtain additional data and to assess the needs for institutional controls;
- Installation of a shallow monitoring well south to southeast of KM-17, and;
- On-site sampling and investigation to identify unmitigated plant-site sources that are contributing to elevated or spiking concentrations to the ground water following periods of increased annual moisture.

9.0 REFERENCES

Dames & Moore, 1991a, RI/FS Work Plan for Soda Springs, Idaho Facility, Kerr-McGee Chemical Company, August 1991.

Dames & Moore, 1991b, Candidate Technology Memorandum, Kerr-McGee Chemical Corporation (KMCC) Soda Springs RI/FS, September 3, 1991.

Dames & Moore, 1992b, Revised May 1992 Sample Plan, Preliminary Site Characterization, Kerr-McGee Soda Springs Facility, Idaho, for Kerr-McGee Chemical Corporation, May 5, 1992.

Dames & Moore, 1995, Final Remedial Investigation Report for the Kerr-McGee Chemical Corporation, Soda Springs, Idaho, April 1995.

Dames & Moore, 1995a, Draft Comparative Analysis Report, Soda Springs, Idaho Facility, Revised Draft Ground Water Modeling Report, February 1995.

Drever, J.I., 1988, The Geochemistry of Natural Waters, 2nd Edition: Prentice Hall Inc., Englewood Cliffs, New Jersey, 437 pp.

Global Environmental Technologies, LLC, 1999, Draft Remedial Action Completion Report for Kerr-McGee Chemical LLC, Soda Springs, Idaho, March 1999.

Global Environmental Technologies, LLC, 2002, Draft Remedial Action Completion Report, Calcine Capping 2000-2001 for Kerr-McGee Chemical LLC, Soda Springs, Idaho, February 2002.

Global Environmental Technologies, LLC, 2011, July 2011 Data Validation Report and Updated Remedial Design/Remedial Action (RD/RA) Database, August, 2011.

Global Environmental Technologies, LLC, 2011, October 2011 Data Validation Report and Updated Remedial Design/Remedial Action (RD/RA) Database, November, 2011.

Global Environmental Technologies, LLC, 2009, Final Ground Water Monitoring Network Evaluation Report for the Kerr-McGee Chemical Superfund Site - Tronox Facility Soda Springs, Idaho dated October 30, 2010.

Golder Associates, 1985 Report on Hydrogeological Investigation, Soda Springs Plant Site, Soda Springs, Idaho, Volumes 1, 2, and 3, prepared for the Monsanto Industrial Chemical Company, November 1985.

Golder Associates, 1992a, Phase I Remedial Investigation/Feasibility Study, Preliminary Site Characterization Summary Report for the Soda Springs Elemental Phosphorus Plant.

Hem, J. D., 1978, Study and Interpretation of the Chemical Characteristics of Natural Water: U.S. Geological Survey Water-Supply Paper 1473, 363 pp.

Isherwood, D.K., 1981, Geoscience Data Base Handbook for Modeling a Nuclear Waste Repository: U.S. Nuclear Regulatory Commission, Office of Nuclear Material Safety and Safeguards Publication, NUREG/CR-0912, v. 2, 331 pp.

Lewis, B.D., and Goldstein, F.J., 1982, Evaluation of a Predictive Ground-Water Solute-Transport Model at the Idaho National Engineering Laboratory, Idaho: U.S. Geological Survey Water Resources Investigations 82-25.

Nace, R.L., Stewart, J.W., Walton, W.C., Barraclough, J.T., Peckham, A.E., Theis, C.V., Johnson, A.I., and McQueen, I.S., 1959, Geography, Geology, and Water Resources of the National Reactor Testing Station, Idaho, Part 3, Hydrology and Water Resources: U.S. Atomic Energy Commission, Idaho Operations Office Publication, IDO-22034-USGS.

Piper, A.M., 1944, A Graphic Procedure in the Geochemical Interpretation of Water Analyses; American Geophysical Union Transactions, v.25, p. 914-923.

Robertson, J.B., 1974, Digital Modeling of Radioactive and Chemical Waste Transport in the Snake River Plain Aquifer at the National Reactor Testing Station, Idaho: U.S. Geological Survey Open-File Report 76-717.

U.S. Environmental Protection Agency, 1994, Draft Human Health and Ecological Risk Assessments for Kerr-McGee Chemical Corporation, Soda Springs, Idaho, October 1993.

U.S. Environmental Protection Agency, 1994, USEPA Contract Laboratory Program National Functional Guidelines for organic and inorganic Data Review, EPA540/R-94/012, February 1994 and December 1994.

U.S. Department of Health and Human Services, Public Health Service, 1990, Draft Toxicological Profile for Vanadium: U.S.H.H.S Public Health Service, Agency for Toxic Substances and Disease Registry.

TABLES

TABLE 1-1
MONITOR WELL CONSTRUCTION AND WELL TESTING RESULTS

Well Designation	Completed Date	Northing*	Easting*	Elevation Top of PVC Feet msl	Elevation Concrete Pad Feet	Top of Screen	Bottom of Screen	Hydraulic Conductivity (ft/day)	Unit Monitored **	Lithology Screened Interval
Tronox Wells										
KM-1	10/07/91	373073.394	659740.078	6029.72	6027.50	45.9	55.9	204	I4	clay, tuff
KM-2	09/21/91	371777.028	660379.196	6025.11	6023.00	47.2	57.2	266	Qb5	basalt, clay
KM-3	10/11/91	371745.657	659825.555	6014.28	6012.20	39.1	49.1	91	I4	clay, tuff
KM-4	10/02/91	372033.826	659695.190	6023.44	6021.90	43.7	53.7	153	I4	cinders, tuff
KM-5	10/01/91	372710.706	658856.602	6002.72	6001.50	38	48	37	Qb5	vesicular basalt
KM-6	09/24/91	371736.929	658601.626	5988.13	5986.00	34.7	44.7	340	Qb5	vesicular basalt
KM-7	09/26/91	372113.189	658578.407	6001.63	5999.90	46.2	56.2	na	Qb5/I4	vesicular basalt and cinders
KM-8	10/21/91	371771.964	658144.161	5976.75	5974.40	34.6	44.6	9.4	Qb5	basalt, clay
KM-9	09/29/91	371770.477	657836.280	5973.56	5971.50	47.5	57.5	48	Qb5	vesicular basalt
KM-10	10/12/91	373073.856	659761.715	6029.43	6027.90	100	120	na	Qb3	basalt
KM-11	10/29/91	371745.582	659847.119	6013.63	6012.10	80	100	96	Qb3	basalt
KM-12	10/29/91	371778.391	658119.553	5976.07	5973.90	134.1	154.1	34	Qb3	basalt
KM-13	10/07/91	372185.749	658042.505	5977.65	5975.60	46.4	56.4	17	Qb5	basalt
KM-15	09/24/92	370332.04	657491.89	5958.10	5956.20	45.2	55.2	105	Qb5a/I5	cinders, basalt
KM-16	09/18/92	371058.74	658151.12	5998.97	5997.20	63.3	73.3	97	Qb5	basalt
KM-17	09/25/92	371100.35	659365.30	6001.11	5999.60	38.2	48.2	2.3	Qb4/I3	basalt, silt
KM-18	10/03/92	370336.14	657468.67	5958.25	5956.80	152.6	172.6	8.2	Qb3	basalt
KM-19	10/15/92	371788.11	658085.74	5975.17	5973.80	193.6	213.6	15	Qb2/I1	fractured basalt, clay
Evergreen Wells										
EV-1	09/05/03	4725177	452418	5951		26	36	na		Gravel, hard basalt
EV-2	09/08/03	4725074	452491	5943		25	35	na		Gravel, broken basalt
EV-3	09/06/03	4724950	452411	5938		26	36	na		Cinders, basalt, hard basalt
EV-4	?	4725070	452378	5945		?	?	na		Unknown
Monsanto Wells										
TW-12	09/14/84	369017.37	656681.35	5939.23	5937.63	89.5	99.5	100	UBZ (I4)	Loose basalt and cinders
TW-33	12/10/84	372526.92	657699.47	5975.68	5974.03	69	74	na	UBZ	Weathered basalt and cinders
TW-38	02/13/85	370446.4	656523.94	5972.91	5970.94	90	102	na	UBZ (Qb5/I5)	Cinders, fresh basalt
TW-56	1992 ?	367979.1	656276.06	5910.2		95	105	na	UBZ (Qb3)	Basalt
Lewis Well	08/15/74	4724126.4	451791.3	5864.35		85	105	100	NA	Crevice basalt, hard basalt

* All coordinates in State Plane Coords except Evergreen and Lewis Wells

** Basalts and interflow stratigraphic units labeled sequentially from QB1/I1 (oldest flow/interflow units) to QB5A/I5 (youngest units)

TABLE 1-2
MAXIMUM CONCENTRATIONS OF COC AND MOST CURRENT** CONCENTRATIONS
IN TRONOX WELLS AND OFF-SITE SPRINGS

Well Designation	Arsenic Concentrations		Manganese Concentrations		Molybdenum Concentrations		Total Petroleum Hydrocarbons Concentrations		Tributyl Phosphate Concentrations		Vanadium Concentrations	
	RBC = 10 ug/l		RBC = 180 ug/l		RBC = 180 ug/l		RBC = 0.73 mg/l		RBC = 180 ug/l		RBC = 260 ug/l	
	Largest (ug/l)	Most Current (ug/l)	Largest (ug/l)	Most Current (ug/l)	Largest (ug/l)	Most Current (ug/l)	Largest (mg/l)	Most Current (mg/l)	Largest (ug/l)	Most Current (ug/l)	Largest (ug/l)	Most Current (ug/l)
KM-2*	53	12	444	27	11800	860	2.0	NA	7	NA	15500	4200
KM-3*	27	11	1680	620	44900	5800	1.8	NA	1400	NA	13200	2400
KM-4	63	8.2	1160	95	15300	1200	NA	NA	NA	NA	23300	5500
KM-5*	12.2	3.3	399	2.0	1460	210	NA	NA	3	NA	15800	1400
KM-6	6.5	5.3	291	210	2140	1300	2.0	NA	110	NA	6630	4200
KM-7	6.9	4.9	197	89	593	350	2.0	NA	NA	NA	3410	2800
KM-8*	170	53	8770	6800	165000	42000	9.5	1.9	4442	850	29000	13000
KM-9*	5	1.2	113	8.5	1740	170	NA	NA	ND	NA	3590	360
KM-11*	2	0.21	157	15	5600	220	0.42	NA	112	NA	492	8.7
KM-12*	23	1.4	177	21	9290	340	0.39	NA	13	NA	5580	490
KM-13*	4	1.2	131	9.5	6790	260	0.18	NA	12	NA	6420	480
KM-15	5.6	2.2	543	40	6950	550	0.15	NA	484	NA	3840	840
KM-16	7.3	3.4	364	120	2300	870	1.9	NA	180	NA	4250	2400
KM-17	1.5	0.38	84	2.1	987	310	1.2	NA	170	NA	493	11
KM-18	3.7	1.6	332	36	6340	450	1.3	NA	410	NA	2990	630
KM-19*	2	0.66	32.3	0.42	258	14	1.1	NA	4	NA	558	100
Big Spring	1.1	0.44	1.8	0.5	508	160	NA	NA	NA	NA	13.6	3.1
Finch Spring	2	0.61	4.4	0.58	663	150	0.22	NA	ND	NA	91.7	53
Upper Ledger	3.7	ND	2.6	ND	22.4	ND	NA	NA	NA	NA	5.1	1.6
Lower Ledger	4.2	ND	1.5	ND	54.1	ND	NA	NA	NA	NA	14.9	1.1

Footnotes:

* = Point of Compliance Well

** = October 2011

NA = Not Available – not sampled during October 2011

ND = Not Detected (less than IDL)

Shaded cells indicate exceedence of RBC

TABLE 3-1

**SAMPLING HISTORY AND SAMPLING RATIONALE FOR REMEDIAL DESIGN/
REMEDIAL ACTION GROUND WATER SAMPLING**

Well/Sample Location	Source Area Monitored	Round 1 Through 8 Sample Events		Round 9 Through 12 Sample Events		RD/RA Sample Events And Low Flow Sampling		
		Sampled? (Yes/No)	Analytes	Sampled? (Yes/No)	Analytes	Sample Site? (Yes/No)	Analytes	Justification For Sampling/Not Sampling
KM-1 (shallow well paired with KM-10)	Lateral gradient background well	Yes	Long-list metals Round 1-3, short-list metals Rounds 4 through 8, radio-nuclides Rounds 1,3, total chromatographable organics Round 1	Yes	Metals, General Indicators, No organics	No	None	Background sampling not needed; relying on RBC performance standards at POC wells and no statistical background comparison
KM-2 (shallow well)	Active calcine tailing impoundment/former scrubber pond area	Yes	Long-list metals Round 1-3, short-list metals Rounds 4 through 8, radio-nuclides Rounds 1, total chromatographable organics Round 1	Yes	Metals, General Indicators, no organics	Yes	Table 4-3 of RD/RA GW SAP and QAPP; No organics	Point of compliance well, although not truly downgradient of calcine or former scrubber pond; monitor changes in ground water concentrations in conjunction with changes at active calcine impoundment area and scrubber pond closure
KM-3 (shallow well paired with KM-11)	Reclaimed scrubber pond	Yes	Long-list metals Round 1-3, short-list metals Rounds 4 through 8, radio-nuclides Rounds 1,3,4 total chromatographable organics Round 1	Yes	Metals, General Indicators, no organics	Yes	Table 4-3 of RD/RA GW SAP and QAPP; no organics	Point of compliance well; monitor changes in ground concentrations water along southern boundary in conjunction with scrubber pond closure
KM-4 (shallow well)	Active calcine tailing impoundment area	Yes	Long-list metals Round 1-3, short-list metals Rounds 4 through 8, radio-nuclides Rounds 1, 3, total chromatographable organics Round 1	No	None	Yes	Table 4-3 of RD/RA GW SAP and QAPP, no organics	Will provide monitoring of calcine impoundment following capping. Not a POC well

TABLE 3-1

**SAMPLING HISTORY AND SAMPLING RATIONALE FOR REMEDIAL DESIGN/
REMEDIAL ACTION GROUND WATER SAMPLING**

Well/Sample Location	Source Area Monitored	Round 1 Through 8 Sample Events		Round 9 Through 12 Sample Events		RD/RA Sample Events And Low Flow Sampling		
		Sampled? (Yes/No)	Analytes	Sampled? (Yes/No)	Analytes	Sample Site? (Yes/No)	Analytes	Justification For Sampling/Not Sampling
KM-5 (shallow well)	Historic scrubber pond/historic MAP ponds, Boiler blowdown pond/downgradient of facility	Yes	Long-list metals Round 1-3, short-list metals Rounds 4 through 8, radio-nuclides Rounds 1,3, total chromatographable organics Round 1	Yes	Metals, General Indicators, no organics	Yes	Table 4-3 of RD/RA GW SAP and QAPP; No organics	Point of compliance well, monitors downgradient of northern and central areas of entire plant facility; no active or historic activities downgradient of this location
KM-6 (shallow well)	Historic limestone Settling ponds	Yes	Long-list metals Round 1-3, short-list metals Rounds 4 through 8, radio-nuclides Rounds 1,3, total chromatographable organics Rounds 1, 3	No	None	Yes	Table 4-3 of RD/RA GW SAP and QAPP; no organics	Monitors zone of increased transmissivity on the southern boundary of facility; not a POC well
KM-7 (shallow well)	Historic calcine impoundment area	Yes	Long-list metals Round 1-3, short-list metals Rounds 4 through 8, radio-nuclides Rounds 1,3, total chromatographable organics Round 1	No	None	Yes (2000-->)	Table 4-3 of RD/RA GW SAP and QAPP; no organics	Monitors central portion of the facility and provides additional justification for contouring of COC; not a POC well
KM-8 (shallow well paired with KM-12 and KM-19)	Former S-X pond/ downgradient of plant facility	Yes	Long-list metals Round 1-3, short-list metals Rounds 4 through 8, metals, radionuclides Rounds 1, 4, total chromatograph-able organics Round 1,3, TPH and semivols Rounds 4 and 8	Yes	Metals, General Indicators	Yes	Table 4-3 of RD/RA GW SAP and QAPP	Point of compliance well; monitor changes in ground water concentrations in conjunction with changes from S-X pond closure

TABLE 3-1

**SAMPLING HISTORY AND SAMPLING RATIONALE FOR REMEDIAL DESIGN/
REMEDIAL ACTION GROUND WATER SAMPLING**

Well/Sample Location	Source Area Monitored	Round 1 Through 8 Sample Events		Round 9 Through 12 Sample Events		RD/RA Sample Events And Low Flow Sampling		
		Sampled? (Yes/No)	Analytes	Sampled? (Yes/No)	Analytes	Sample Site? (Yes/No)	Analytes	Justification For Sampling/Not Sampling
KM-9 (shallow well)	Former S-X pond/downgradient of plant facility	Yes	Long-list metals Round 1-3, short-list metals Rounds 4 through 8, radio-nuclides Rounds 1,3, total chromatographable organics Round 1	Yes	Metals, General Indicators, no organics	Yes	Table 4-3 of RD/RA GW SAP and QAPP; No organics	Point of compliance well, downgradient of entire facility; comparisons can be made with ground water model results to track and evaluate performance
KM-10 (intermediate well, paired with KM-1)	Intermediate depth background well	Yes	Long-list metals Round 1-3, short-list metals Rounds 4 through 8, radio-nuclides Rounds 1,3, total chromatographable organics Round 1	Yes	Metals, General Indicators, no organics	No	None	Background sampling not needed; relying on RBC performance standards at POC wells and no statistical background comparison
KM-11 (intermediate well, paired with KM-3)	Former scrubber pond	Yes	Long-list metals Round 1-3, short-list metals Rounds 4 through 8, radio-nuclides Rounds 1,3, total chromatographable organics Round 1	Yes	Metals, General Indicators, no organics	Yes	Table 4-3 of RD/RA GW SAP and QAPP; No organics	Point of compliance well; monitor changes in ground water concentrations in conjunction with scrubber pond closure
KM-12 (intermediate well paired with KM-8, KM-19)	Former S-X pond/downgradient of plant facility	Yes	Long-list metals Round 1-3, short-list metals Rounds 4 through 8, radio-nuclides Round 1, total chromatographable organics Round 1	No	None	Yes	Table 4-3 of RD/RA GW SAP and QAPP, no organics	Point of compliance well; monitor changes in ground water concentrations in conjunction with changes from S-X pond closure
KM-13 (shallow well)	Former S-X pond (north end) and downgradient of plant facility	Yes	Long-list metals Round 1-3, short-list metals Rounds 4 through 8, radio-nuclides Round 1, total chromatographable organics Round 1	Yes	Metals, General Indicators, no organics	Yes	Table 4-3 of RD/RA GW SAP and QAPP; no organics	Point of compliance well, downgradient of entire facility

TABLE 3-1

**SAMPLING HISTORY AND SAMPLING RATIONALE FOR REMEDIAL DESIGN/
REMEDIAL ACTION GROUND WATER SAMPLING**

Well/Sample Location	Source Area Monitored	Round 1 Through 8 Sample Events		Round 9 Through 12 Sample Events		RD/RA Sample Events And Low Flow Sampling		
		Sampled? (Yes/No)	Analytes	Sampled? (Yes/No)	Analytes	Sample Site? (Yes/No)	Analytes	Justification For Sampling/Not Sampling
KM-15 (shallow well, paired with KM-18)	Off-site well southwest of former S-X pond and within main area of impacted ground water	Not completed prior to Round 5	Long-list metals Round 5, short-list metals Rounds 6 through 8, semivols and TPH Rounds 5-8	Yes	Metals, General Indicators	Yes	Table 4-3 of RD/RA GW SAP and QAPP, no organics	Located in off-site area near modeled point; current RBC exceedences of Mo, and V
KM-16 (shallow well)	Off-site well south of former S-X and settling ponds	Not completed prior to Round 5	Long-list metals Round 5, short-list metals Rounds 6 through 8, semivols and TPH Rounds 5-8	Yes	Metals, General Indicators	Yes	Table 4-3 of RD/RA GW SAP and QAPP, no organics	Located off-site and laterally downgradient of the site; RBC exceedences of Mo, and V
KM-17 (shallow well)	Off-site well southwest of former scrubber pond and active calcine tailing	Not completed prior to Round 5	Long-list metals Round 5, short-list metals Rounds 6 through 8, semivols and TPH Rounds 5-8	Yes	Metals, General Indicators	Yes	Table 4-3 of RD/RA GW SAP and QAPP, no organics	Located off-site and laterally downgradient of the site; RBC exceedences of Mo
KM-18 (intermediate well, paired with KM-15)	Off-site well southwest of former S-X pond, pond and within main area of impacted ground water, paired with KM-15	Not completed prior to Round 5	Long-list metals, semivols and TPH Rounds 5-8	Yes	Metals, General Indicators	Yes	Table 4-3 of RD/RA GW SAP and QAPP, no organics	Monitors deeper aquifer zone for ground water impact; current RBC exceedences Mo, and V
KM-19 (deep well paired with KM-8 and KM-12)	Former S-X pond and downgradient of plant facility	Not completed prior to Round 5	Long-list metals Round 5, short-list metals Rounds 6 through 8, semivols and TPH Round 5	No	None	Yes	Table 4-3 of RD/RA GW SAP and QAPP, no organics	Point of compliance well; monitor changes in ground water concentrations in conjunction with changes from S-X pond closure

TABLE 3-1

**SAMPLING HISTORY AND SAMPLING RATIONALE FOR REMEDIAL DESIGN/
REMEDIAL ACTION GROUND WATER SAMPLING**

Well/Sample Location	Source Area Monitored	Round 1 Through 8 Sample Events		Round 9 Through 12 Sample Events		RD/RA Sample Events And Low Flow Sampling		
		Sampled? (Yes/No)	Analytes	Sampled? (Yes/No)	Analytes	Sample Site? (Yes/No)	Analytes	Justification For Sampling/Not Sampling
Finch Spring (spring discharging from base of Finch Fault to surface water)	Spring south of facility which has appeared to be impacted primarily from scrubber discharge	Yes	Long-list metals Round 1-3, short-list metals Rounds 4 through 8, long-list metals, semivolts and TPH Round 5	Yes	Metals, General Indicators	Yes	Table 4-3 of RD/RA GW SAP and QAPP, no organics	Monitor downgradient changes to ground water from scrubber pond closure and other remedial actions on-site, current RBC exceedence of Mo
Big Spring (spring discharging to surface water flowing to Bear River)	Spring south of Soda Springs, furthest south discharge identified from Bear River Basin to Bear River	Not sampled prior to Round 6	Short-list metals	Yes	Metals, General Indicators, no organics	Yes	Table 4-3 of RD/RA GW SAP and QAPP, no organics	Current exceedence of Mo RBC, too far from plant to measure direct changes associated with remedial actions; other influencing factor contributing to ground water upgradient of site and downgradient of KMCC, will continue to monitor
Upper Ledge(r) Spring (spring discharging from Ledger Creek drainage, between Kelley Park and Rabbit Mountain)	An important source of drinking water for the town of Soda Springs. EPA requested additional monitoring of this spring by KMC LLC following public meeting and on amended ROD comments in June 2000.	1 Event (no impacts noted)	Long-list metals Round 1	No	None	Yes	Table 4-3 of RD/RA GW SAP and QAPP, no organics	Monitor ground water quality

TABLE 3-1

**SAMPLING HISTORY AND SAMPLING RATIONALE FOR REMEDIAL DESIGN/
REMEDIAL ACTION GROUND WATER SAMPLING**

Well/Sample Location	Source Area Monitored	Round 1 Through 8 Sample Events		Round 9 Through 12 Sample Events		RD/RA Sample Events And Low Flow Sampling		
		Sampled? (Yes/No)	Analytes	Sampled? (Yes/No)	Analytes	Sample Site? (Yes/No)	Analytes	Justification For Sampling/Not Sampling
Lower Ledge(r) Spring (spring discharging from Ledger Creek drainage, between Kelley Park and Rabbit Mountain)	An important source of drinking water for the town of Soda Springs. EPA requested additional monitoring of this spring by KMC LLC following public meeting and on amended ROD comments in June 2000.	1 Event (no impacts noted)	Long-list metals Round 1	No	None	Yes	Table 4-3 of RD/RA GW SAP and QAPP, no organics	Monitor ground water quality

TABLE 5-1
CHRONOLOGY OF PROCESS CHANGES

Event	Date(s)	Comments
S-X stream diverted from the S-X pond to the scrubber pond	1992 through 1993	Flow may have been diverted between ponds during this time period.
MAP ponds taken out of service; third roaster taken off-line in April	1993	Ponds reclaimed. Effects of remediation apparent in well KM-5.
S-X pond receiving discharge from S-X circuit	1994	S-X circuit discharge diverted to S-X pond for last time.
S-X stream diverted from the S-X pond to the scrubber pond	Late 1994 to mid 1995	S-X pond contained residual process water during 1995
S-X stream diverted to newly-constructed lined ponds	Mid 1995	Precipitation continued to fill the S-X pond basin and infiltrate. Pond contained significant volume of precipitation during 1996-1997 winter.
Scrubber pond taken out of service	April 1997	Scrubber pond pumped to the calcine pond. Some scrubber stream sent to calcine ponds. Residual liquid in pond and meteoric water drained out during stabilization of the pond sediments. All baghouses on-line in October.
Discontinue sluicing calcine	April – October 1997	Calcine dewatered, and residual water recycled in process. Dewatered calcine stockpiled north of the calcine impoundment.
Fertilizer Plant Operational	July 1998 to May 2000	Calcine removed from active calcine impoundment, processed to fertilizer. Reject fertilizer placed in calcine impoundment.
Discontinue Vanadium Processing – Vanadium Plant Idle	January 1999 to present	Discontinue stockpiling of calcine, discontinue all vanadium process streams to lined ponds, discontinue the recycle of roaster reject.
Cap Active Calcine Impoundment	May 2001 through August 2001	Calcine was capped using multi-component cover to eliminate meteoric infiltration through calcine tailing. Substantial amount of dust control/construction water used.
Dismantle Vanadium Plant	November 2001 through May 2002	Materials removed to approved facility, surface footprint cleaned in preparation for surface regrade. Footprint regraded with limestone fines in April/May 2003
Dismantle Fertilizer Plant	November 2002 through June 2003	Materials removed to approved facility, surface footprint cleaned in preparation for surface regrade.
Reclaim Stormwater Runoff Ponds	September through October 2003	Solids and liquids removed to 10-acre pond, site regraded and reclaimed.
Reclaim 5-Acre Ponds	September through October 2004	Solids and liquids removed to 10-acre pond, east pond site regraded and reclaimed.
Regrade Scrubber Pond Cover	November 2005	Fill and regrade south of calcine cap

Note: Changes in the discharge locations of both the S-X and scrubber streams affected concentrations in both on-site and off-site wells and Finch Spring during operation.

TABLE 6-1
PROJECTED COC TRENDS
BASED ON NOVEMBER 1997 THROUGH OCTOBER 2011 DATA

Monitor Well	MANGANESE					MOLYBDENUM				
	October 2011 Conc. (ug/l)	Projected Year Below RBC	Mn Regression Equation	Mn Coefficient of Determination	Mn Correlation Coefficient	October 2011 Conc. (ug/l)	Projected Year Below RBC	Mo Regression Equation	Mo Coefficient of Determination	Mo Correlation Coefficient
KM-2*	27	Below RBC				860	2022	$y = 3E+08e-3E-04x$	$R^2 = 0.7545$	0.87
KM-3*	620	Increasing Trend	$y = 0.289e0.0002x$	$R^2 = 0.3887$	0.62	5800	2100	$y = 2E+07e-2E-04x$	$R^2 = 0.4776$	0.69
KM-4	95	Below RBC				1200	NE			
KM-5*	2	Below RBC				210	2008	$y = 22657e-1E-04x$	$R^2 = 0.3894$	0.62
KM-6	210	Below RBC				1300	2046	$y = 326527e-1E-04x$	$R^2 = 0.5001$	0.71
KM-7	89	Below RBC				350	NE			
KM-8*	6800	Increasing Trend	$y = 2486.3e1E-05x$	$R^2 = 0.0012$	0.03	42000	>2050	$y = 1E+08e-2E-04x$	$R^2 = 0.6065$	0.78
KM-9*	8.5	Below RBC				170	Below RBC			
KM-11*	15	Below RBC				220	NE			
KM-12*	21	Below RBC				340	2018	$y = 1E+07e-3E-04x$	$R^2 = 0.9583$	0.98
KM-13*	9.5	Below RBC				260	2012	$y = 4E+07e-3E-04x$	$R^2 = 0.7614$	0.87
KM-15	40	Below RBC				550	2020	$y = 1E+06e-2E-04x$	$R^2 = 0.603$	0.78
KM-16	120	Below RBC				870	2030	$y = 986755e-2E-04x$	$R^2 = 0.636$	0.80
KM-17	2.1	Below RBC				310	2023	$y = 99487e-1E-04x$	$R^2 = 0.5925$	0.77
KM-18	36	Below RBC				450	2019	$y = 2E+06e-2E-04x$	$R^2 = 0.7075$	0.84
KM-19*	0.42	Below RBC				14	Below RBC			

SHADED CELL INDICATES CURRENT EXCEEDENCE OF RBC

* - Indicates Point of Compliance Well

NE - Not evaluated for COC projection

TABLE 6-1
PROJECTED COC TRENDS
BASED ON NOVEMBER 1997 THROUGH OCTOBER 2011 DATA

VANADIUM					
Monitor Well	October 2011 Conc. (ug/l)	Projected Year Below RBC	Regression Equation	V Coefficient of Determination	V Correlation Coefficient
KM-2*	4200	2045	$y = 7E+06e-2E-04x$	$R^2 = 0.7669$	0.88
KM-3*	2400	2069	$y = 116595e-1E-04x$	$R^2 = 0.2364$	0.49
KM-4	5500	NE			
KM-5*	1400	2037	$y = 327178e-1E-04x$	$R^2 = 0.5632$	0.75
KM-6	4200	2097	$y = 90181e-8E-05x$	$R^2 = 0.3487$	0.59
KM-7	2800	NE			
KM-8*	13000	Increasing Trend	$y = 2163.5e5E-05x$	$R^2 = 0.0413$	0.20
KM-9*	360	2015	$y = 628475e-2E-04x$	$R^2 = 0.9358$	
KM-11*	8.7	Below RBC			
KM-12*	490	2021	$y = 700221e-2E-04x$	$R^2 = 0.9624$	0.98
KM-13*	480	2020	$y = 105277e-1E-04x$	$R^2 = 0.8708$	0.93
KM-15	840	2032	$y = 167062e-1E-04x$	$R^2 = 0.8412$	0.92
KM-16	2400	2058	$y = 269501e-1E-04x$	$R^2 = 0.7444$	0.86
KM-17	11	Below RBC			
KM-18	630	2024	$y = 327563e-2E-04x$	$R^2 = 0.9233$	0.96
KM-19*	100	Below RBC			

SHADED CELL INDICATES CURRENT EXCEEDENCE OF RBC

* - Indicates Point of Compliance Well

NE - Not evaluated for COC projection

TABLE 6-2
PROJECTED COC TREND
BASED ON MAY 2004 THROUGH OCTOBER 2011 DATA

Monitor Well	MANGANESE					MOLYBDENUM				
	October 2011 Conc. (ug/l)	Mn Projected Year Below RBC	Mn Regression Equation	Mn Coefficient of Determination	Mn Correlation Coefficient	October 2011 Conc. (ug/l)	Mo Projected Year Below	Mo Regression Equation	Mo Coefficient of Determination	Mo Correlation Coefficient
KM-2*	27	Below RBC				860	2028	$y = 1E+07e-2E-04x$	$R^2 = 0.7372$	0.86
KM-3*	620	Increasing Trend				5800	>2080	$y = 324509e-1E-04x$	$R^2 = 0.7055$	0.84
KM-4	95	Below RBC				1200	NE			
KM-5*	2	Below RBC				210	2058	$y = 203.84e-2E-06x$	$R^2 = 9E-05$	0.01
KM-6	210	Below RBC				1300	>2100	$y = 10894e-5E-05x$	$R^2 = 0.0726$	0.27
KM-7	89	Below RBC				350	NE			
KM-8*	6800	Increasing Trend	$y = 0.0001e0.0004x$	$R^2 = 0.4118$	0.64	42000	Increasing Trend	$y = 6799.2e4E-05x$	$R^2 = 0.0273$	0.17
KM-9*	8.5	Below RBC				170	Below RBC			
KM-11*	15	Below RBC				220	NE			
KM-12*	21	Below RBC				340	2017	$y = 3E+07e-3E-04x$	$R^2 = 0.9664$	0.98
KM-13*	9.5	Below RBC				260	2018	$y = 17998e-1E-04x$	$R^2 = 0.2025$	0.45
KM-15	40	Below RBC				550	2084	$y = 1603.2e-3E-05x$	$R^2 = 0.0273$	0.17
KM-16	120	Below RBC				870	2100	$y = 4157.2e-4E-05x$	$R^2 = 0.0516$	0.23
KM-17	2.1	Below RBC				310	2018	$y = 1E+06e-2E-04x$	$R^2 = 0.7823$	0.88
KM-18	36	Below RBC				450	2040	$y = 6530.7e-7E-05x$	$R^2 = 0.1301$	0.36
KM-19*	0.42	Below RBC				14	Below RBC			

SHADED CELL INDICATES EXCEEDENCE OF RBC

* - Indicates point of compliance wells

NE - Indicates not evaluated for COC projected trend

TABLE 6-2
PROJECTED COC TREND
BASED ON MAY 2004 THROUGH OCTOBER 2011 DATA

Monitor Well	VANADIUM				
	October 2011 Conc. (ug/l)	V Projected Year Below RBC	V Regression Equation	V Coefficient of Determination	V Correlation Coefficient
KM-2*	4200	>2100	$y = 15625e-3E-05x$	$R^2 = 0.0945$	0.31
KM-3*	2400	2057	$y = 300962e-1E-04x$	$R^2 = 0.129$	0.36
KM-4	5500	NE			
KM-5*	1400	>2100	$y = 2686.3e-2E-05x$	$R^2 = 0.0088$	0.09
KM-6	4200	>2100	$y = 6740e-1E-05x$	$R^2 = 0.0038$	0.06
KM-7	2800	NE			
KM-8*	13000	2060	$y = 6E+07e-2E-04x$	$R^2 = 0.3869$	0.62
KM-9*	360	2019	$y = 44085e-1E-04x$	$R^2 = 0.7885$	0.89
KM-11*	8.7	Below RBC			
KM-12*	490	2020	$y = 2E+06e-2E-04x$	$R^2 = 0.9558$	0.98
KM-13*	480	2028	$y = 55041e-1E-04x$	$R^2 = 0.618$	0.79
KM-15	840	2059	$y = 10700e-6E-05x$	$R^2 = 0.4293$	0.66
KM-16	2400	>2100	$y = 13541e-4E-05x$	$R^2 = 0.1397$	0.37
KM-17	11	Below RBC			
KM-18	630	2031	$y = 48181e-1E-04x$	$R^2 = 0.7556$	0.87
KM-19*	100	Below RBC			

SHADED CELL INDICATES EXCEEDENCE OF RBC

* - Indicates point of compliance wells

NE - Indicates not evaluated for COC projected trend

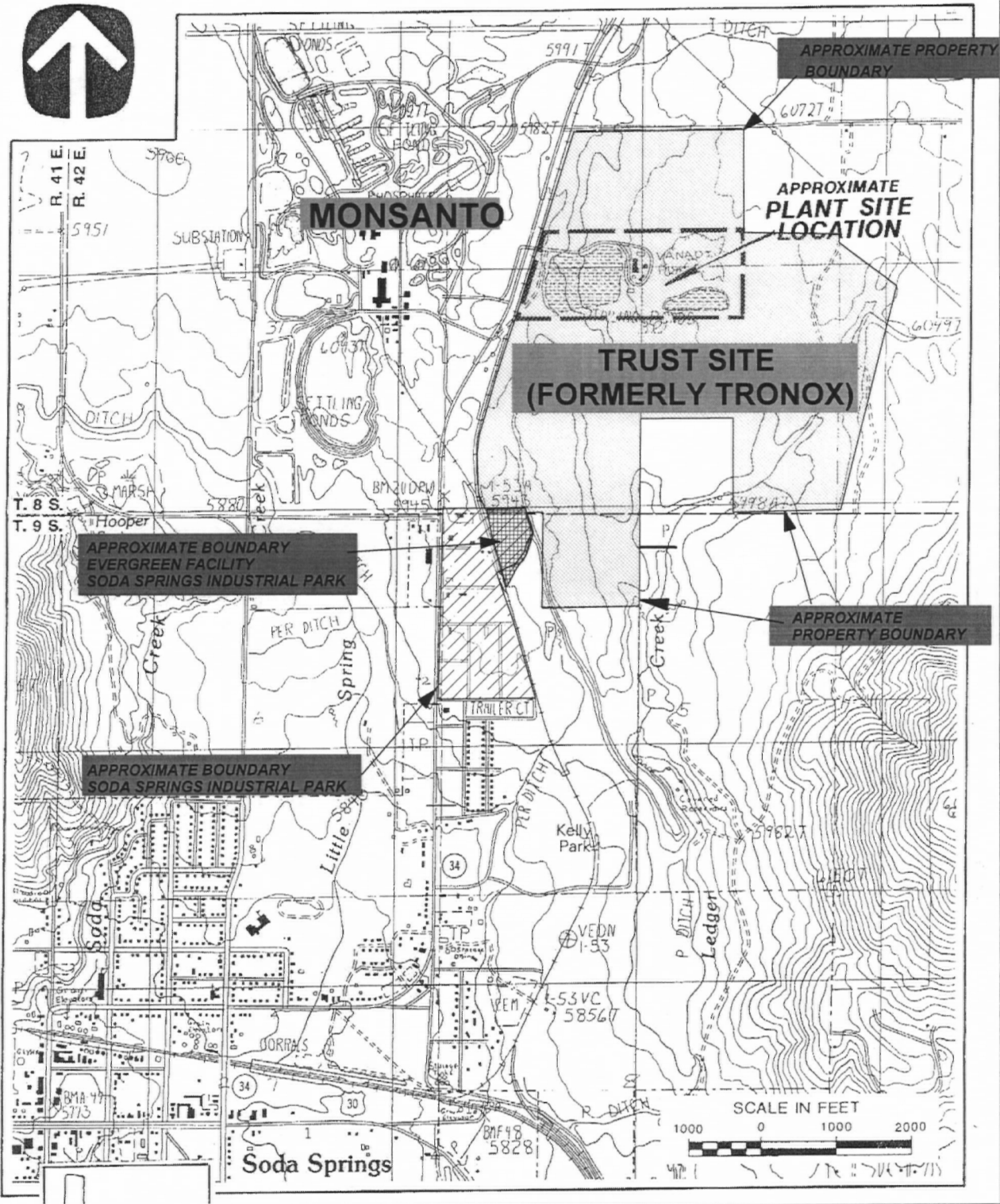
TABLE 8-1
LONG-TERM GROUND AND SURFACE MONITORING RECOMMENDATIONS

Well ID	Well/Spring Use	COC Exceeding RBC	ROD Clean-up Achieved?	Comment	Source Area Monitored	Recommended Long-Term Sampling Frequency
KM-1	Shallow Background	NA	NA	Water level monitored	Lateral gradient background well - not sampled	Water levels only
KM-2	POC Well	As, Mo, V	No	Seasonal COC fluctuation	Active calcine tailing impoundment/former scrubber pond area	Semiannual
KM-3	POC Well	As, Mn, Mo, V	No	Seasonal COC fluctuation	Reclaimed scrubber pond	Semiannual
KM-4	Internal Facility Monitoring	As, Mo, V	No		Active calcine tailing impoundment area	Semiannual
KM-5	POC Well	V	No	Achieved Mo cleanup level	Historic scrubber pond/historic MAP ponds, Boiler blowdown pond/downgradient of facility	Annual
KM-6	Edge of Facility Monitoring	As, Mo, V	No	Seasonal COC fluctuation	Historic Limestone Settling Ponds/Zone of large transmissivity	Semiannual
KM-7	Internal Facility Monitoring		No		Historic calcine impoundment area	Annual
KM-8	POC Well	As, Mn, Mo, V	No	Seasonal COC fluctuation	Former S-X pond/ downgradient of plant facility	Semiannual
KM-9	POC Well	V	No	Achieved Mo cleanup level	Former S-X pond/downgradient of plant facility	Semiannual
KM-10	Intermediate Depth Background	NA	NA	Water level monitored	Intermediate depth background well	Water levels only
KM-11	Intermediate Depth POC Well	Mo	No		Former scrubber pond	Semiannual

TABLE 8-1
LONG-TERM GROUND AND SURFACE MONITORING RECOMMENDATIONS

Well ID	Well/Spring Use	COC Exceeding RBC	ROD Clean-up Achieved?	Comment	Source Area Monitored	Recommended Long-Term Sampling Frequency
KM-12	Intermediate Depth POC Well	Mo, V	No		Former S-X pond/ downgradient of plant facility	Semiannual
KM-13	POC Well	Mo, V	No		Former S-X pond (north end) and downgradient of plant facility	Semiannual
KM-15	Off-Site Well	Mo, V	No	Seasonal COC fluctuation	Off-site well southwest of former S-X pond and within main area of impacted ground water	Semiannual
KM-16	Off-Site Well	Mo, V	No	Seasonal COC fluctuation	Off-site well south of former S-X and settling ponds and within main area of impacted ground water	Semiannual
KM-17	Off-Site Well	Mo	No		Off-site well southwest of former scrubber pond and active calcine tailing	Semiannual
KM-18	Intermediate Depth Off-Site Well	Mo, V	No	Seasonal COC fluctuation	Off-site well southwest of former S-X pond, pond and within main area of impacted ground water, paired with KM-15	Semiannual
KM-19	POC Deep Well	None	Yes		Former S-X pond and downgradient of plant facility	Annual
Upper Ledger	Water Supply	None			Downgradient of facility	Semiannual
Lower Ledger	Water Supply	None			Downgradient of facility	Semiannual
Finch Spring	Monitor off-site COC	Mo	No		Downgradient of facility	Semiannual
Big Spring	Monitor off-site COC	Mo	No		Downgradient of facility	Semiannual

FIGURES

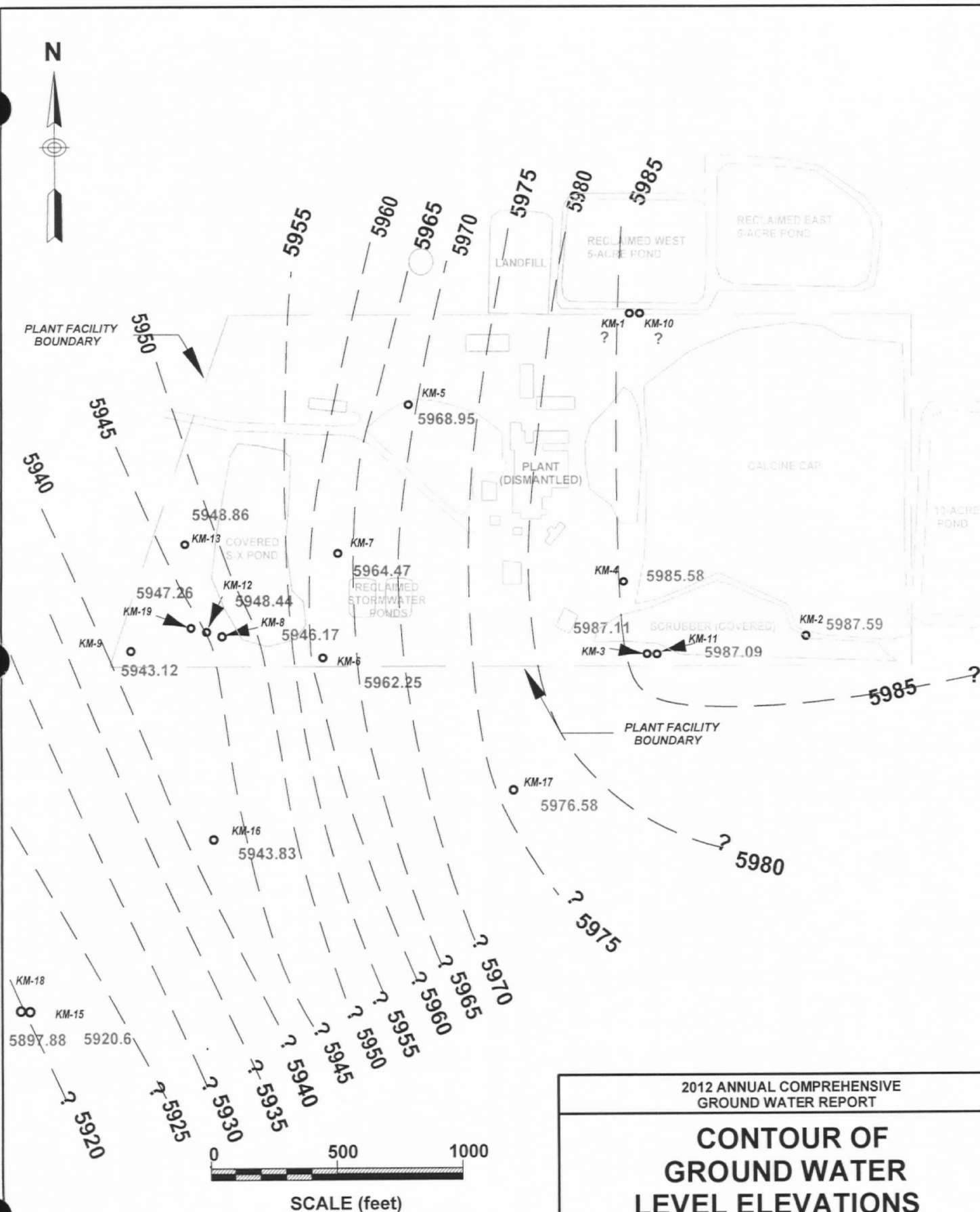


REFERENCE: U.S.G.S. QUADRANGLE
SODA SPRINGS, IDAHO PROVISIONAL
EDITION 1982.

ANNUAL COMPREHENSIVE GROUND AND
SURFACE WATER REPORT

APPROXIMATE TRUST PROPERTY BOUNDARY LOCATION MAP

FIGURE 1-1



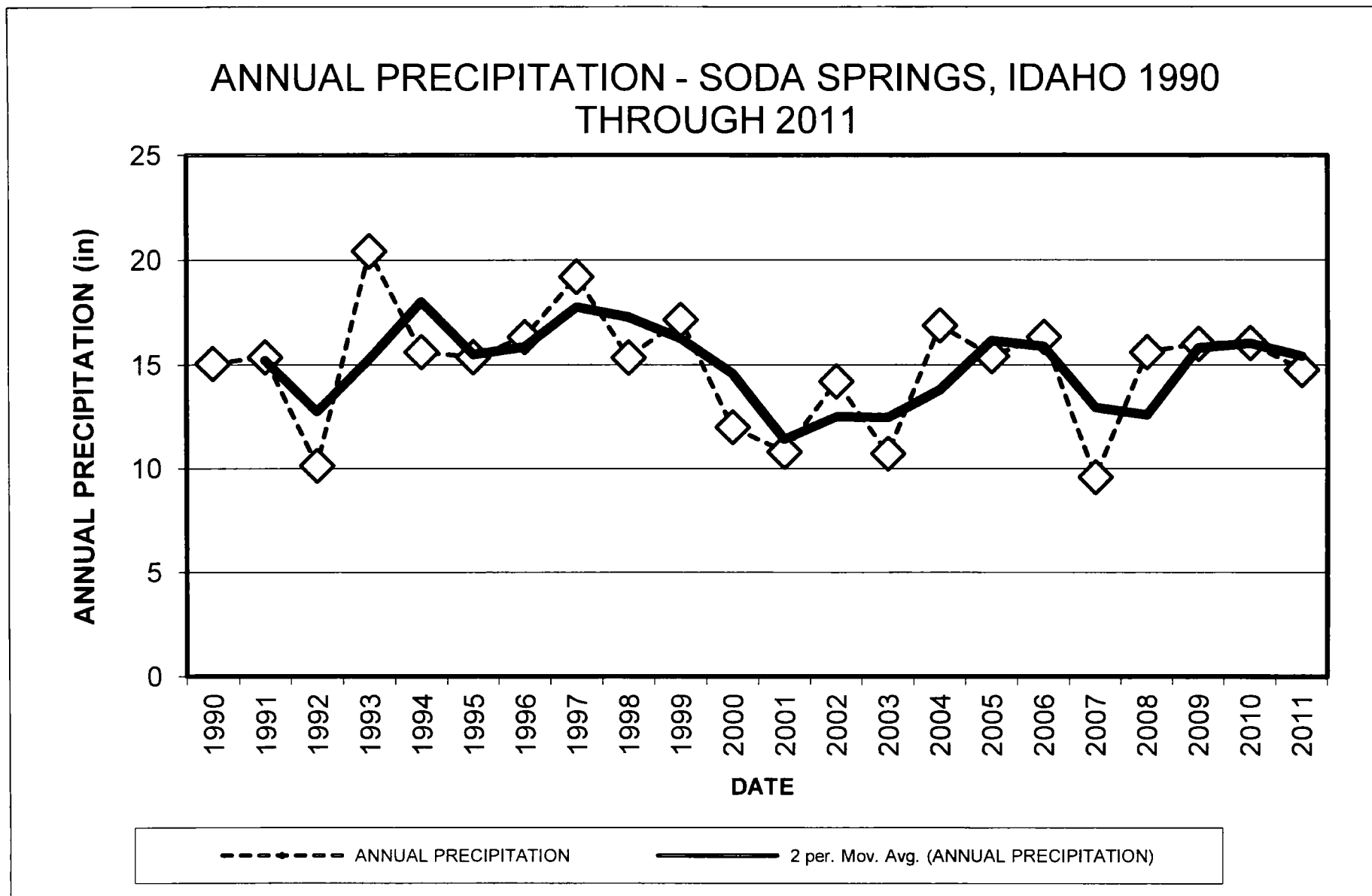
NOTE: CONTOURS BASED ON GROUND WATER LEVELS IN SHALLOW WELLS

2012 ANNUAL COMPREHENSIVE
GROUND WATER REPORT

CONTOUR OF GROUND WATER LEVEL ELEVATIONS JULY 2011

GREENFIELD TRUST
SODA SPRINGS, IDAHO

FIGURE 1-2



**WATER LEVELS VERSUS TIME
TRUST ON-SITE WELLS
FOLLOWING LSE AND POND RECLAMATION**

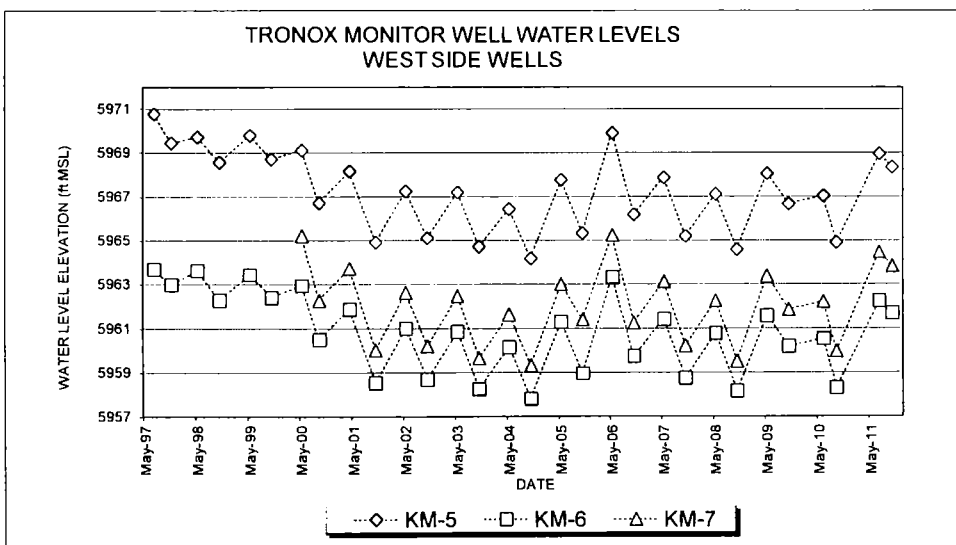
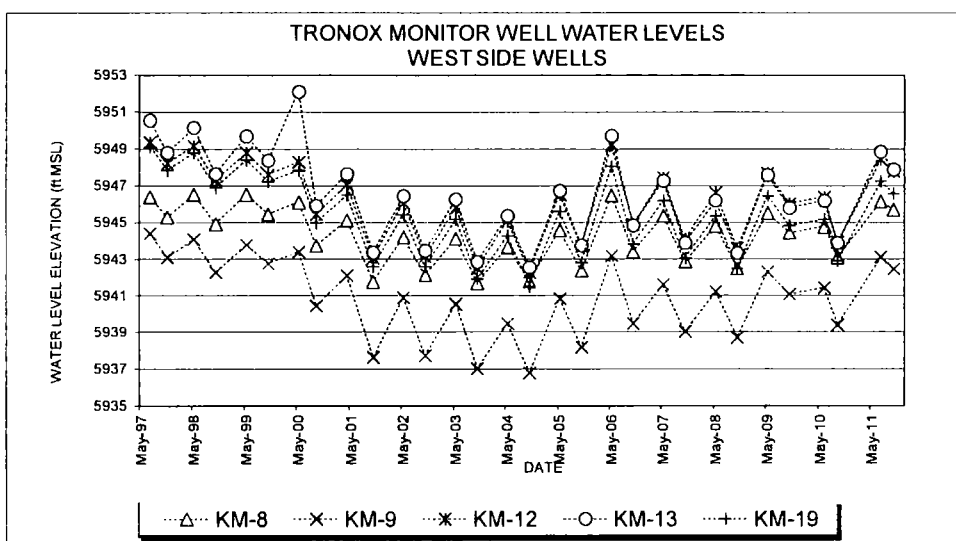
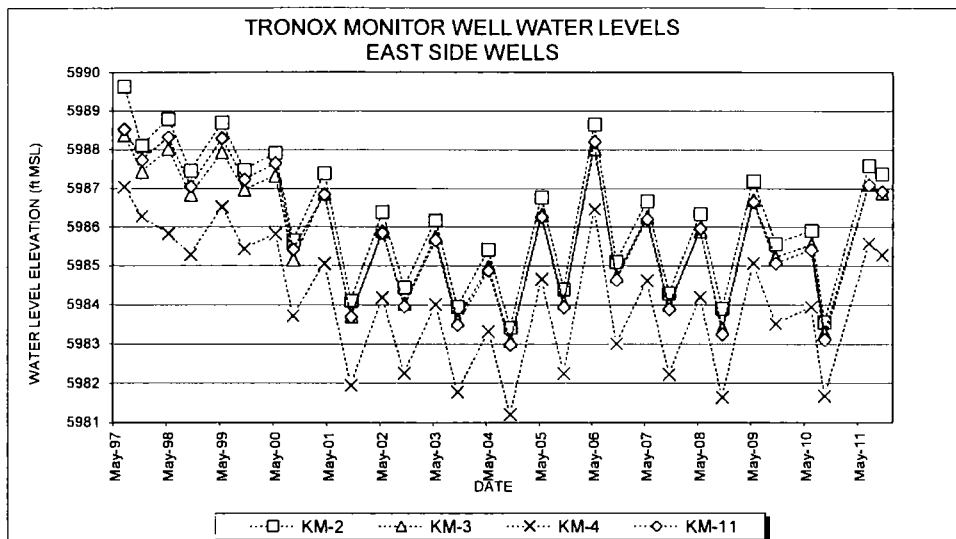
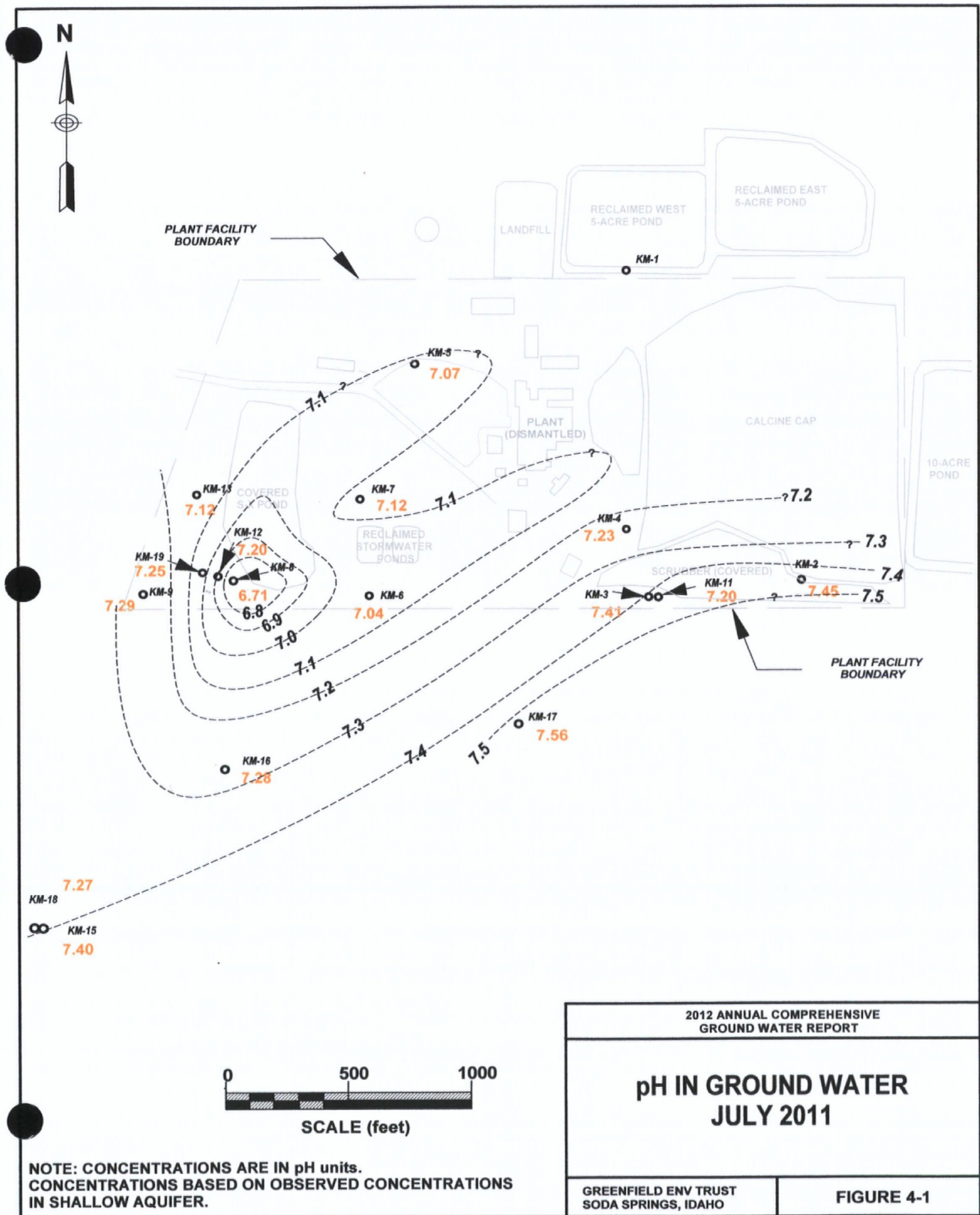
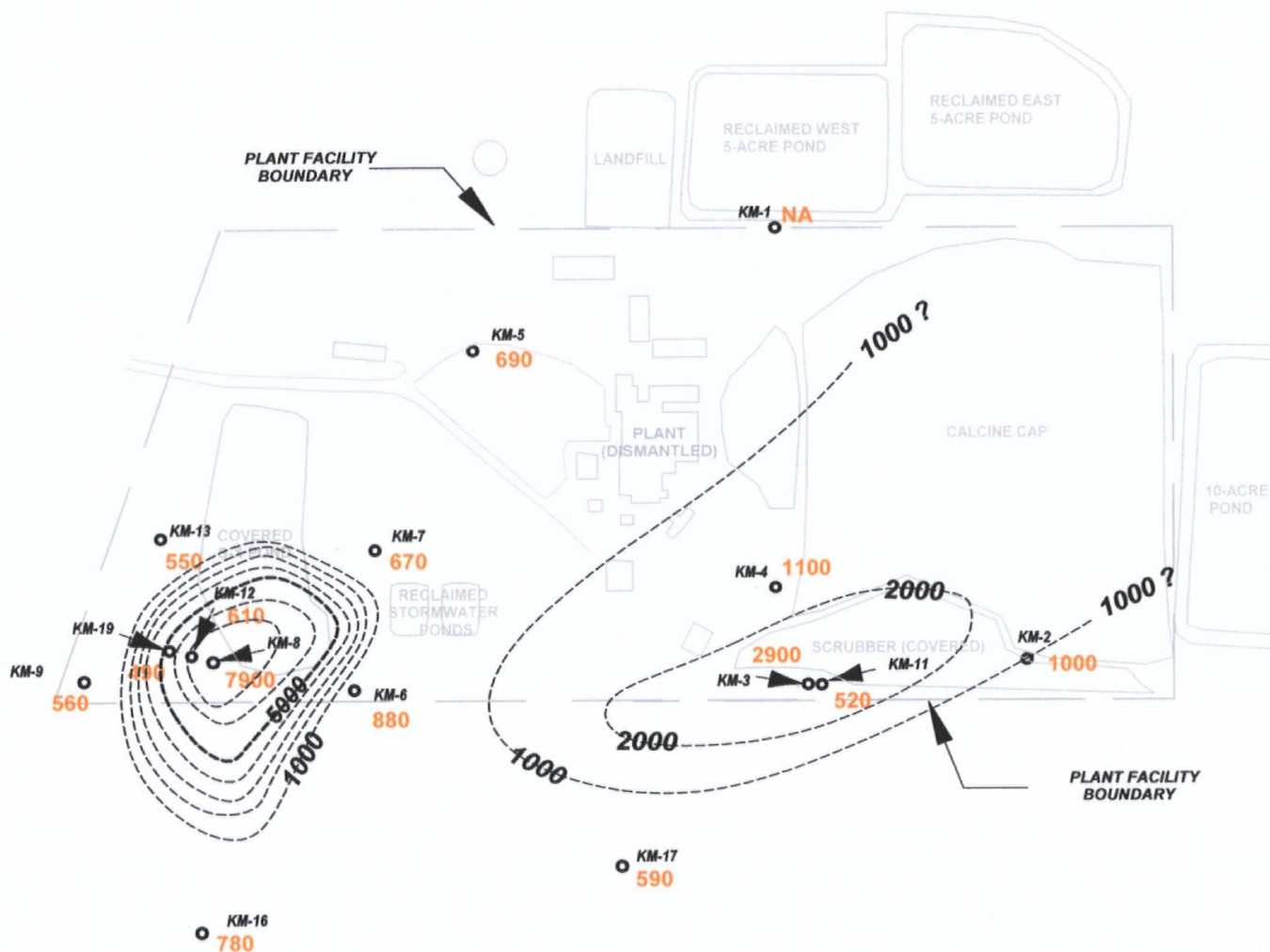


FIGURE 2-2





KM-18
640
KM-15
680



SCALE (feet)

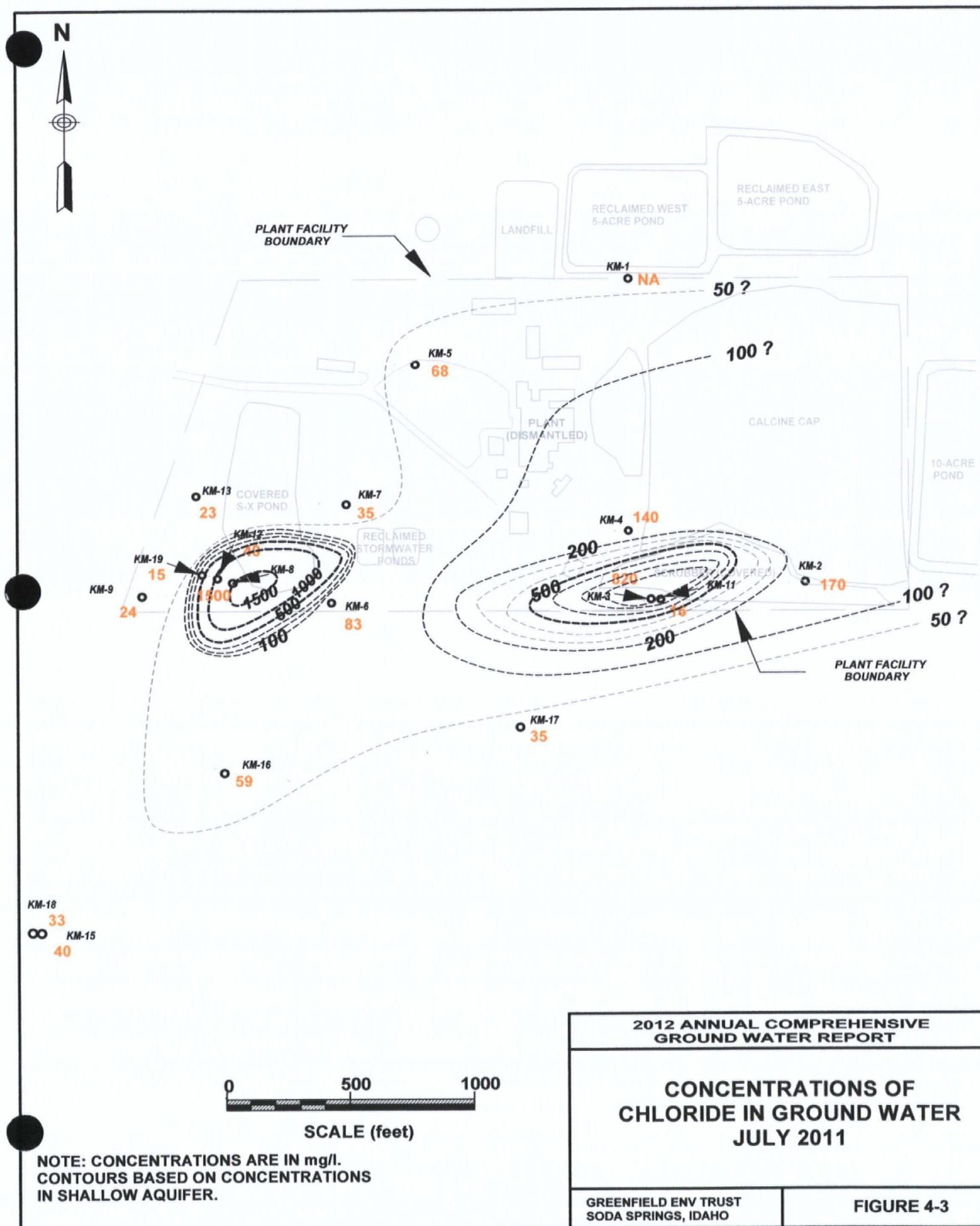
NOTE: CONCENTRATIONS ARE IN mg/l.
CONTOURS BASED ON CONCENTRATIONS
IN SHALLOW AQUIFER.

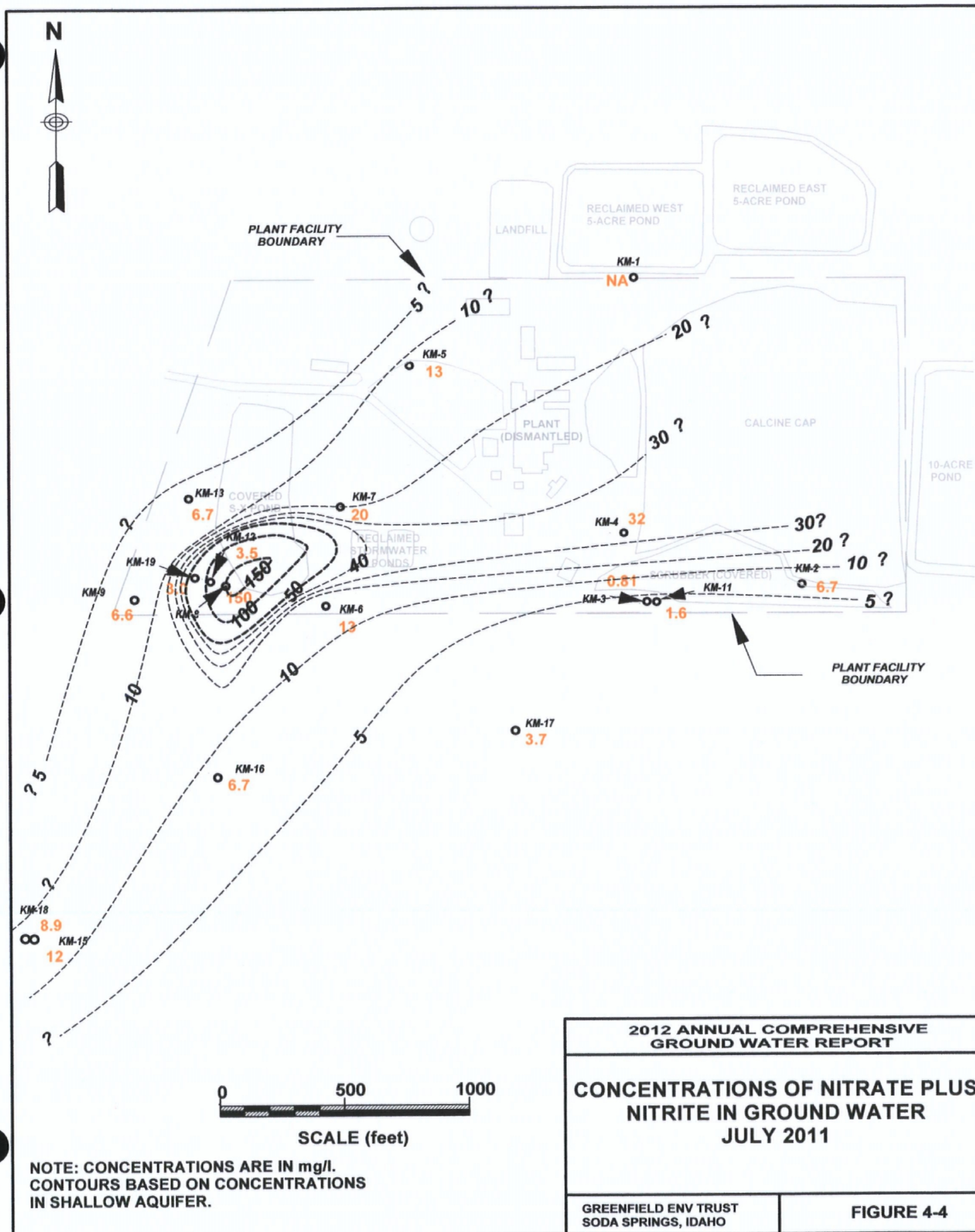
2012 ANNUAL COMPREHENSIVE
GROUND WATER REPORT

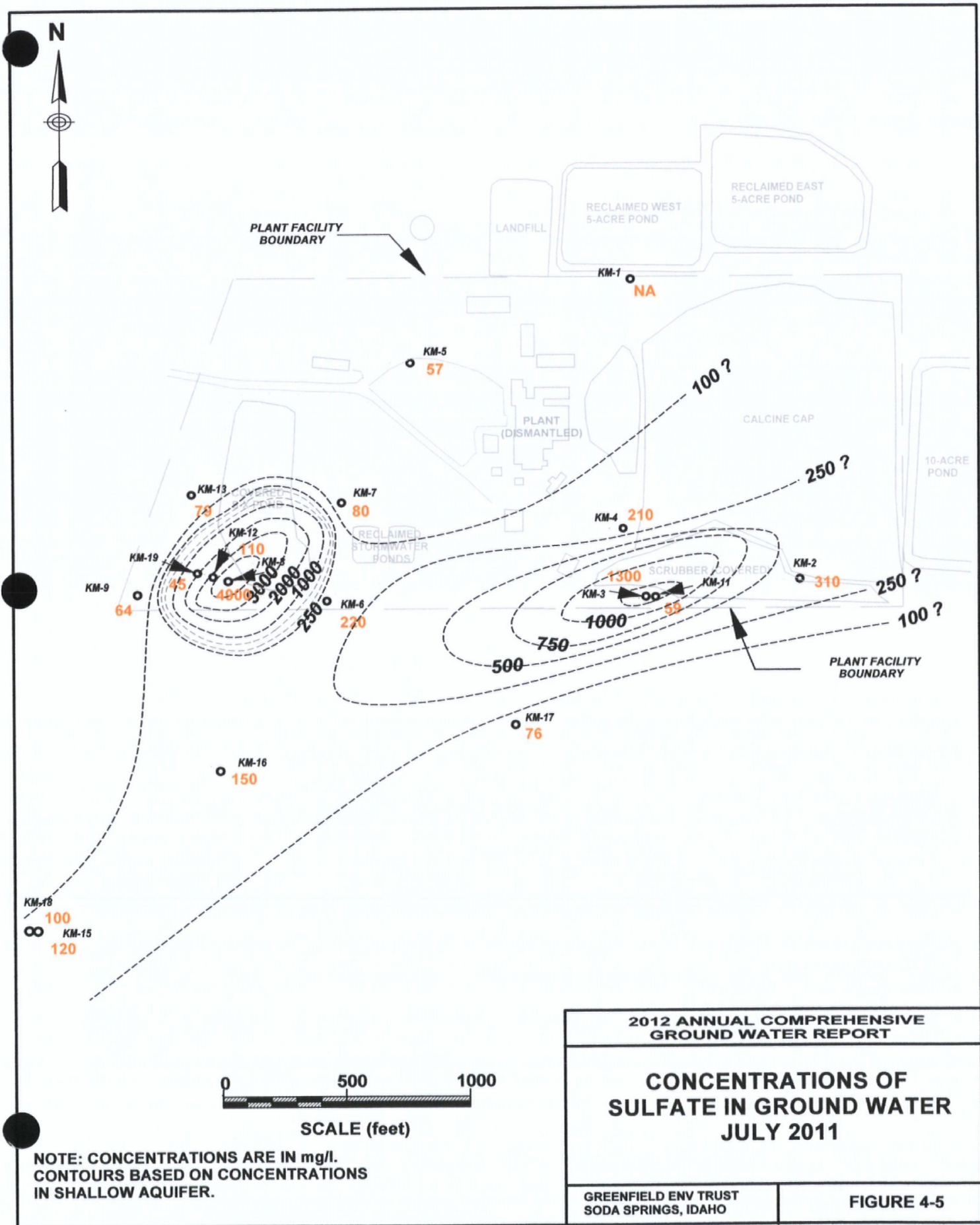
CONCENTRATIONS OF
TDS IN GROUND WATER
JULY 2011

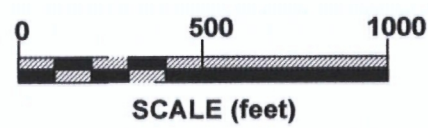
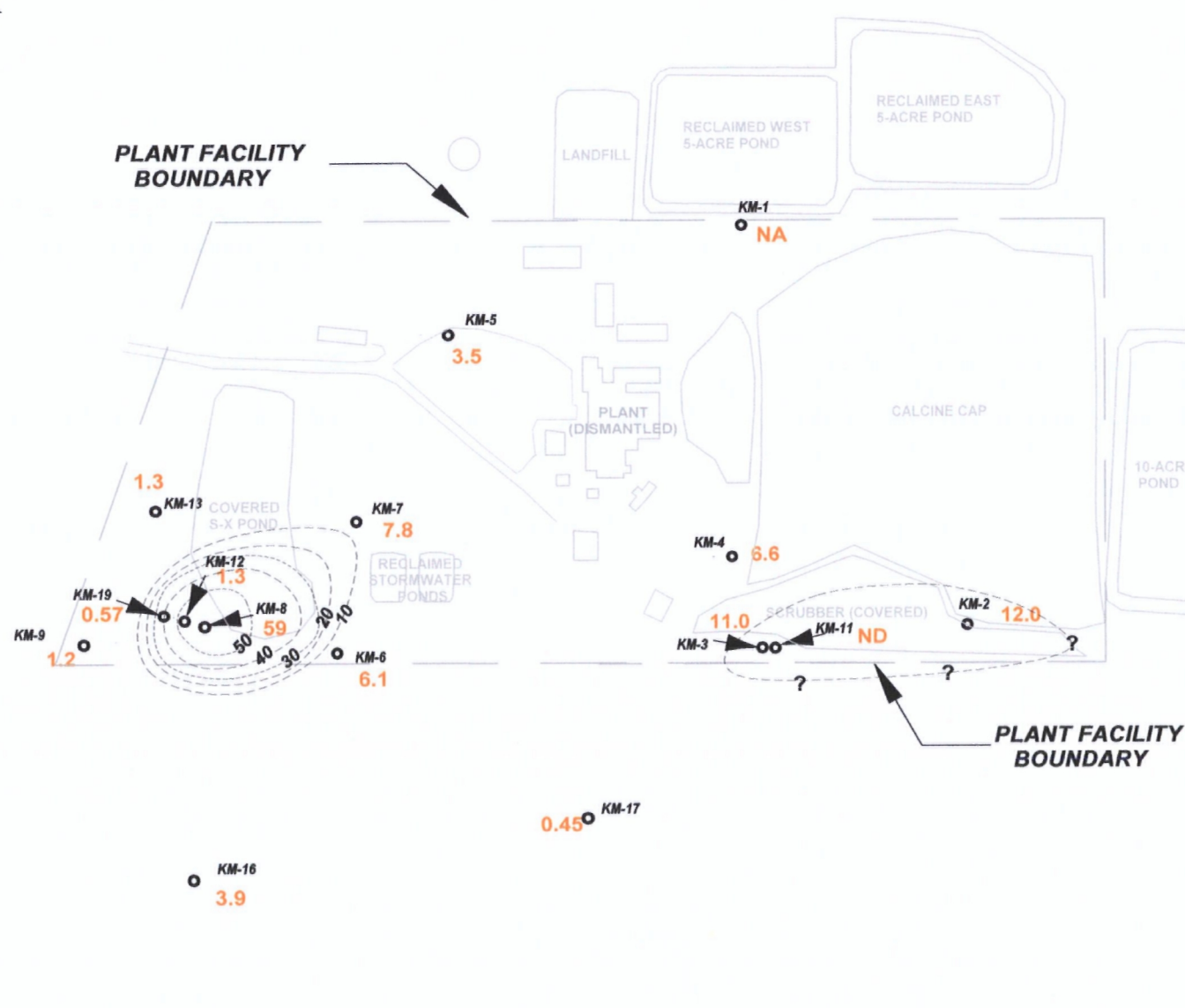
GREENFIELD ENV TRUST
SODA SPRINGS, IDAHO

FIGURE 4-2







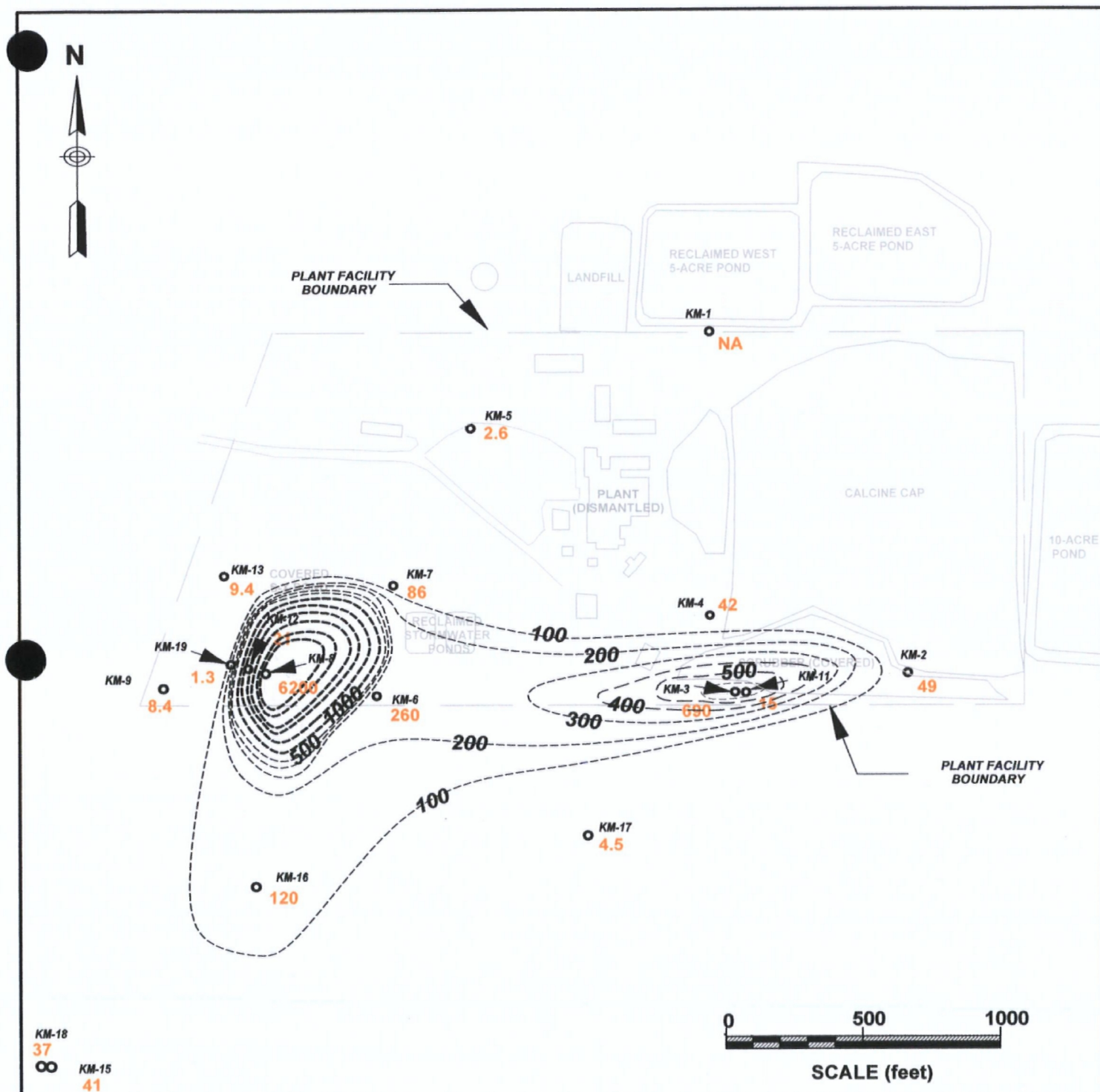


2012 ANNUAL COMPREHENSIVE
GROUND WATER REPORT

CONCENTRATIONS OF ARSENIC IN GROUND WATER JULY 2011

GREENFIELD ENV TRUST
SODA SPRINGS, IDAHO

FIGURE 4-6





PLANT FACILITY
BOUNDARY

LANDFILL

RECLAIMED WEST
5-ACRE POND

RECLAIMED EAST
5-ACRE POND

KM-1
NA

KM-5
270

500 ?

PLANT
(DISMANTLED)

CALCINE CAP

KM-7
460

KM-4
910

KM-13
310

KM-12
350

RECLAIMED
STORMWATER
POND

KM-19

KM-9
190

16

310

310

310

310

310

310

310

310

310

310

310

310

310

310

310

310

310

310

310

310

310

310

310

310

310

KM-6
1500

4000

5000

6200

230

5000

1000 ?

2000 ?

3000 ?

3000 ?

2000 ?

1000 ?

PLANT FACILITY
BOUNDARY

KM-17
250

KM-16
940

500

1000

500

KM-18
520

KM-15
620



SCALE (feet)

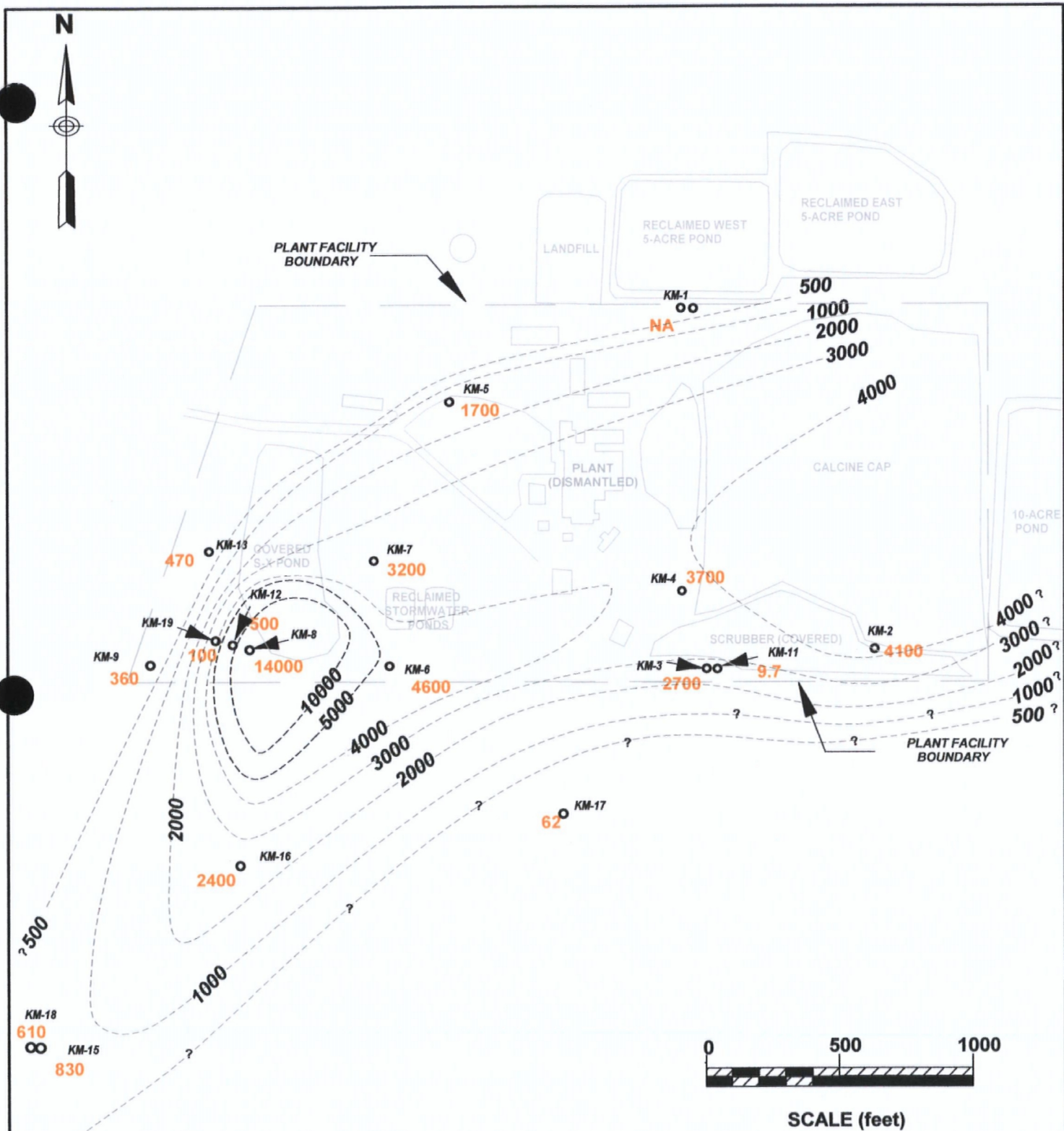
NOTE: CONCENTRATIONS ARE IN ug/l.
CONTOURS BASED ON CONCENTRATIONS
IN SHALLOW AQUIFER.
RBC FOR MOLYBDENUM IS 180 ug/l.

2012 ANNUAL COMPREHENSIVE
GROUND WATER REPORT

CONCENTRATIONS OF MOLYBDENUM IN GROUND WATER JULY 2011

GREENFIELD ENV TRUST
SODA SPRINGS, IDAHO

FIGURE 4-8

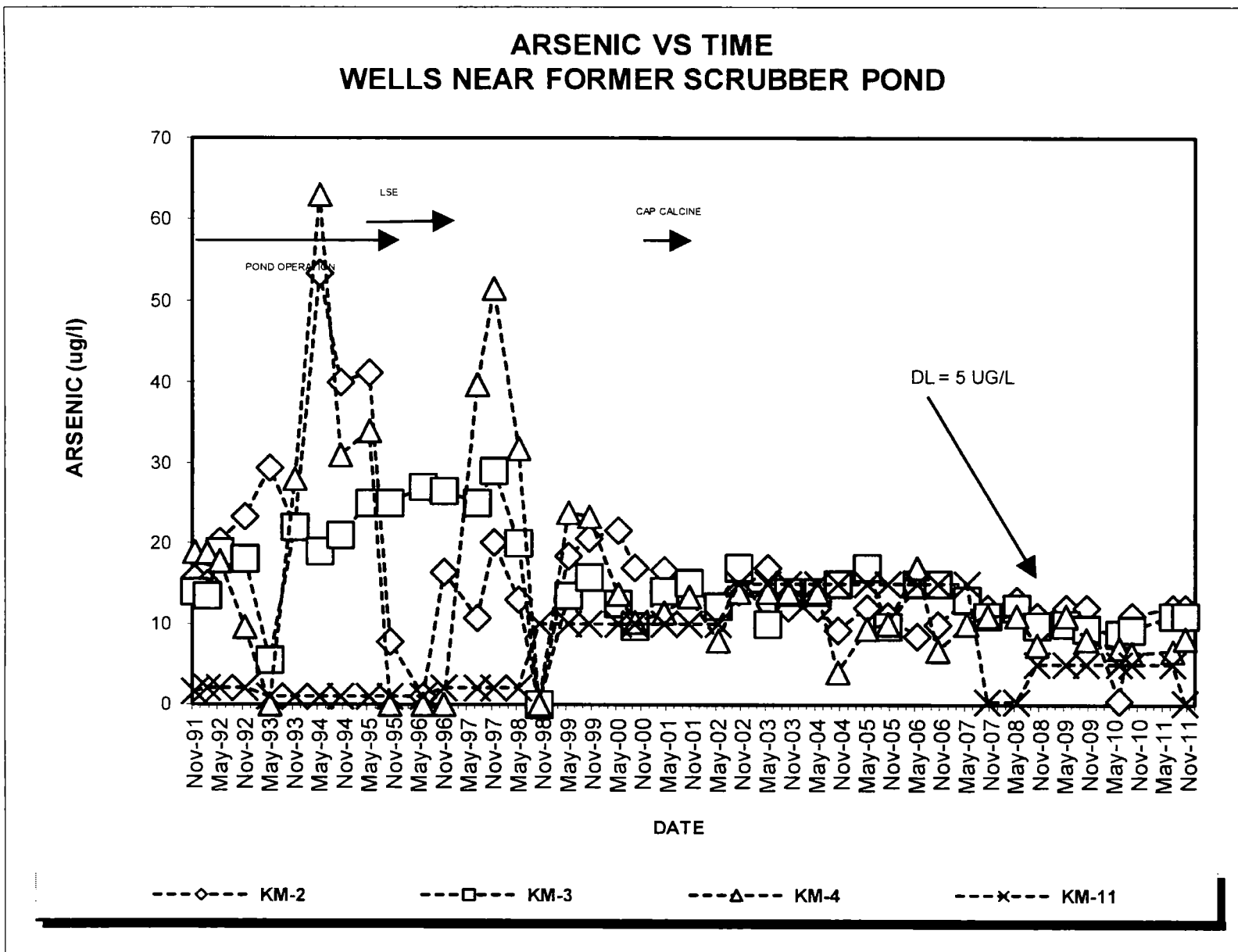


NOTE: CONCENTRATIONS ARE IN ug/l.
 CONCENTRATIONS BASED ON OBSERVED CONCENTRATIONS
 IN SHALLOW AQUIFER.
 RBC FOR VANADIUM IS 260 ug/l .

2012 ANNUAL COMPREHENSIVE GROUND WATER REPORT	
CONCENTRATIONS OF VANADIUM IN GROUND WATER JULY 2011	
GREENFIELD ENV TRUST SODA SPRINGS, IDAHO	FIGURE 4-9

APPENDIX A

**GRAPHS OF GROUND AND SURFACE WATER
QUALITY VERSUS TIME**

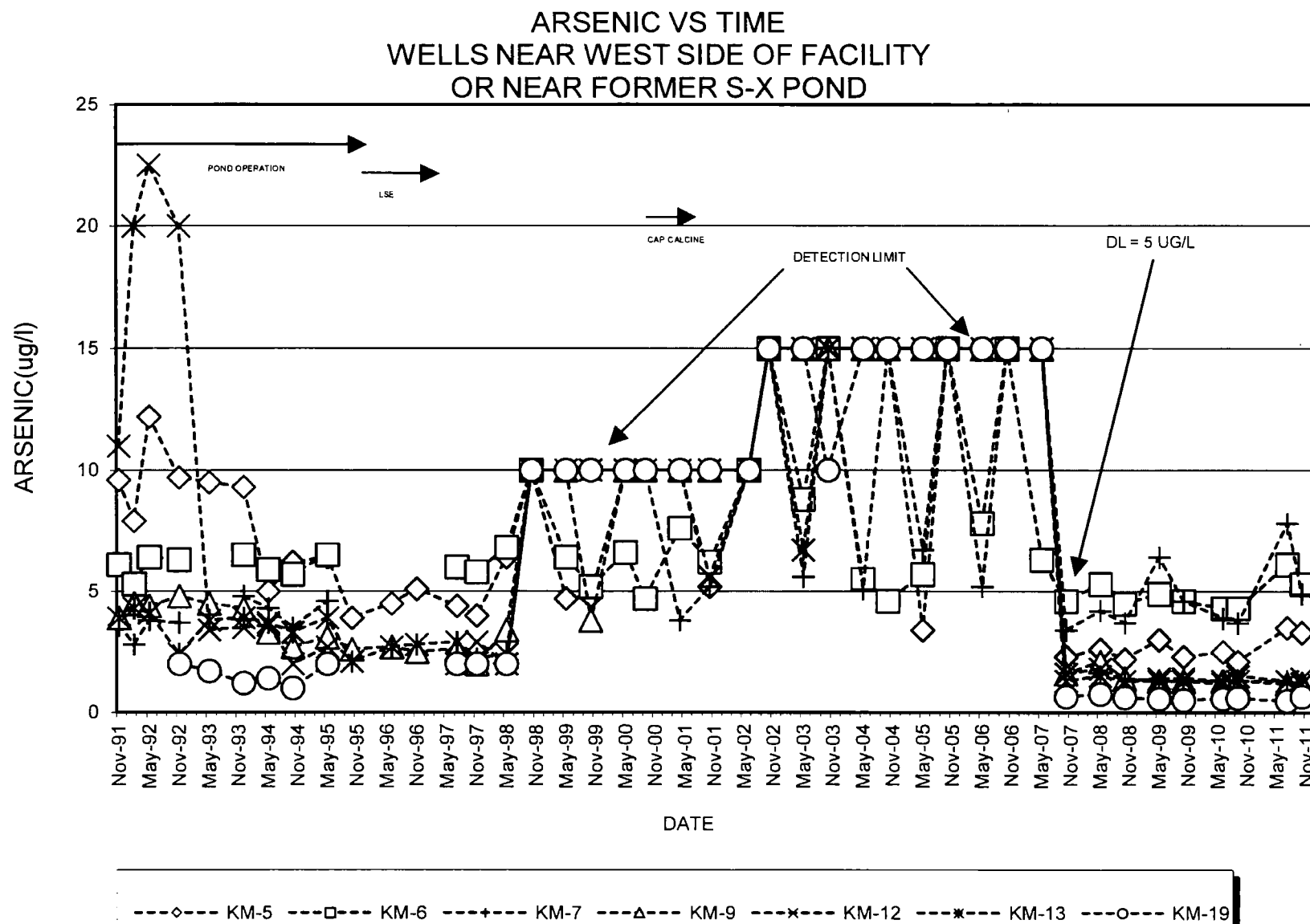


RBC FOR ARSENIC IS 10 ug/l

KM-2, KM-3, KM-11 ARE POC WELLS

VALUES LESS THAN DETECTION ARE PLOTTED AT DETECTION LIMIT

ARSENIC DETECTION LIMIT AT 10 TO 15 UG/L 1999 THROUGH 2007

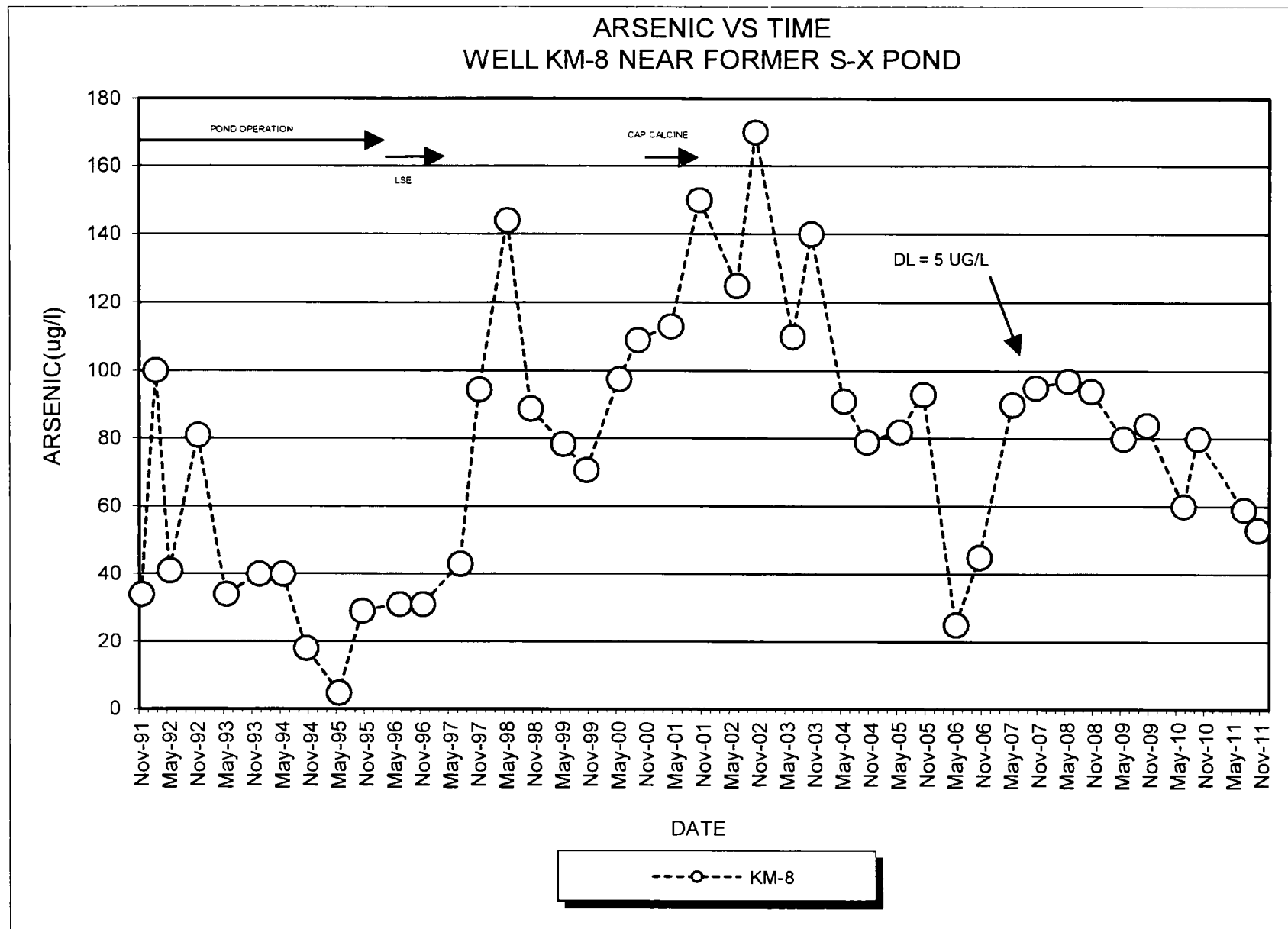


RBC FOR ARSENIC IS 10 ug/l

KM-5, KM-9, KM-12, KM-13, KM-19 ARE POC WELLS

VALUES LESS THAN DETECTION ARE PLOTTED AT THE DETECTION LIMIT

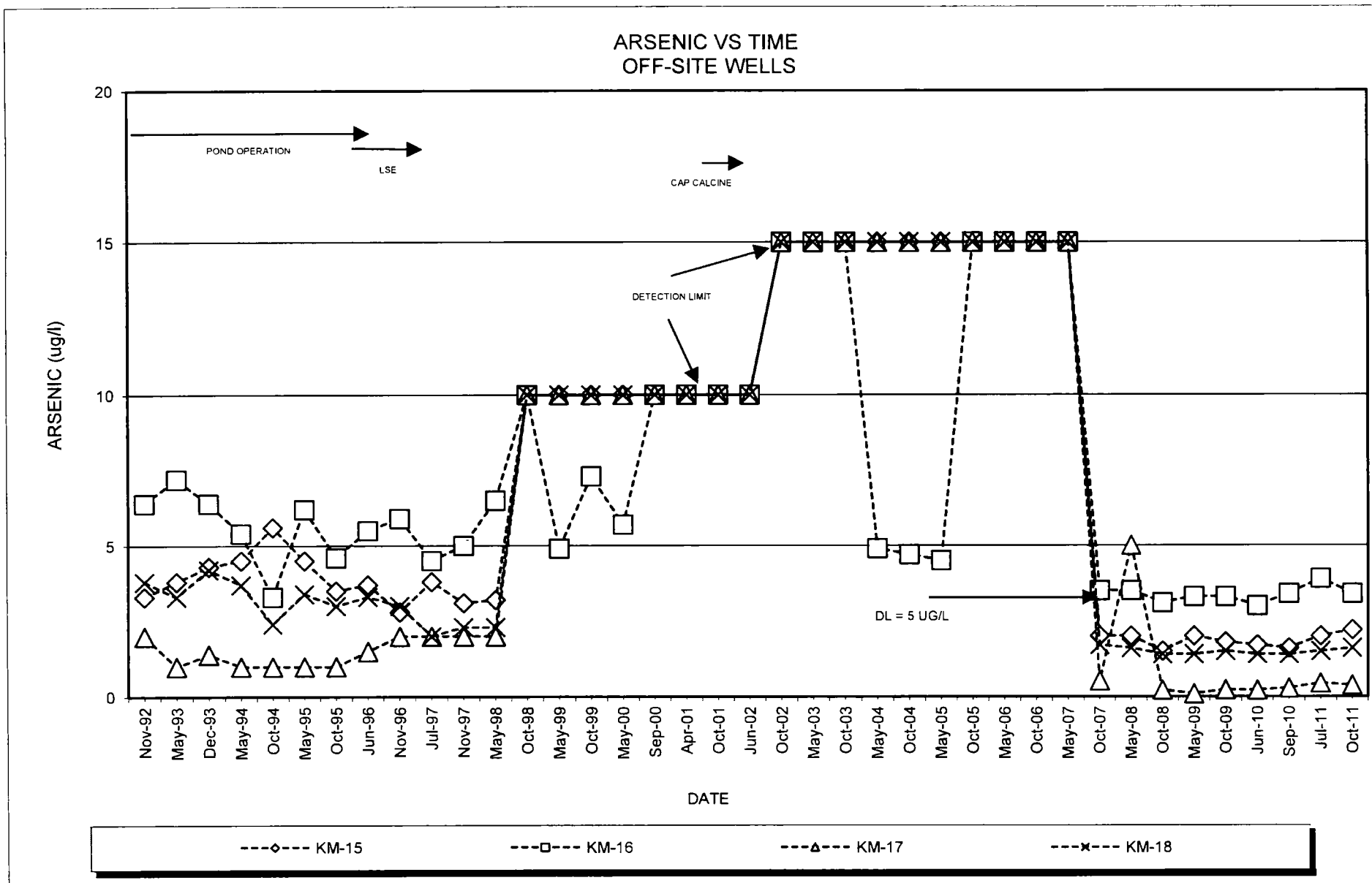
ARSENIC IS LESS THAN DETECTION OR REPORTING LIMIT IN ALL WELLS DURING 2003 through May 2007



RBC FOR ARSENIC IS 10 ug/l

KM-8 IS A POC WELL

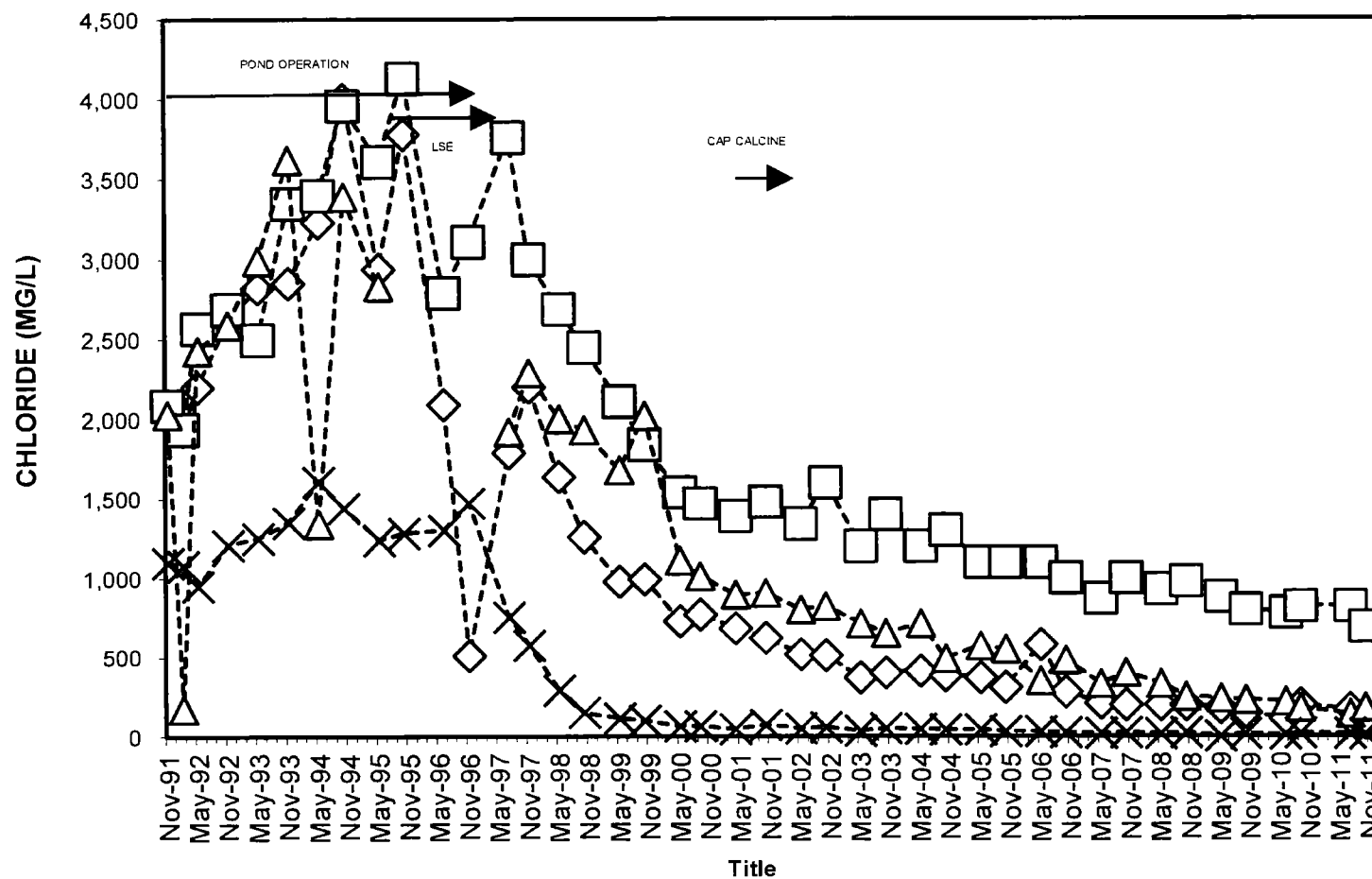
VALUES LESS THAN DETECTION ARE PLOTTED AT THE DETECTION LIMIT



RBC = 10 ug/l

Values less than detection plotted at the detection limit

CHLORIDE VS TIME WELLS NEAR FORMER SCRUBBER POND



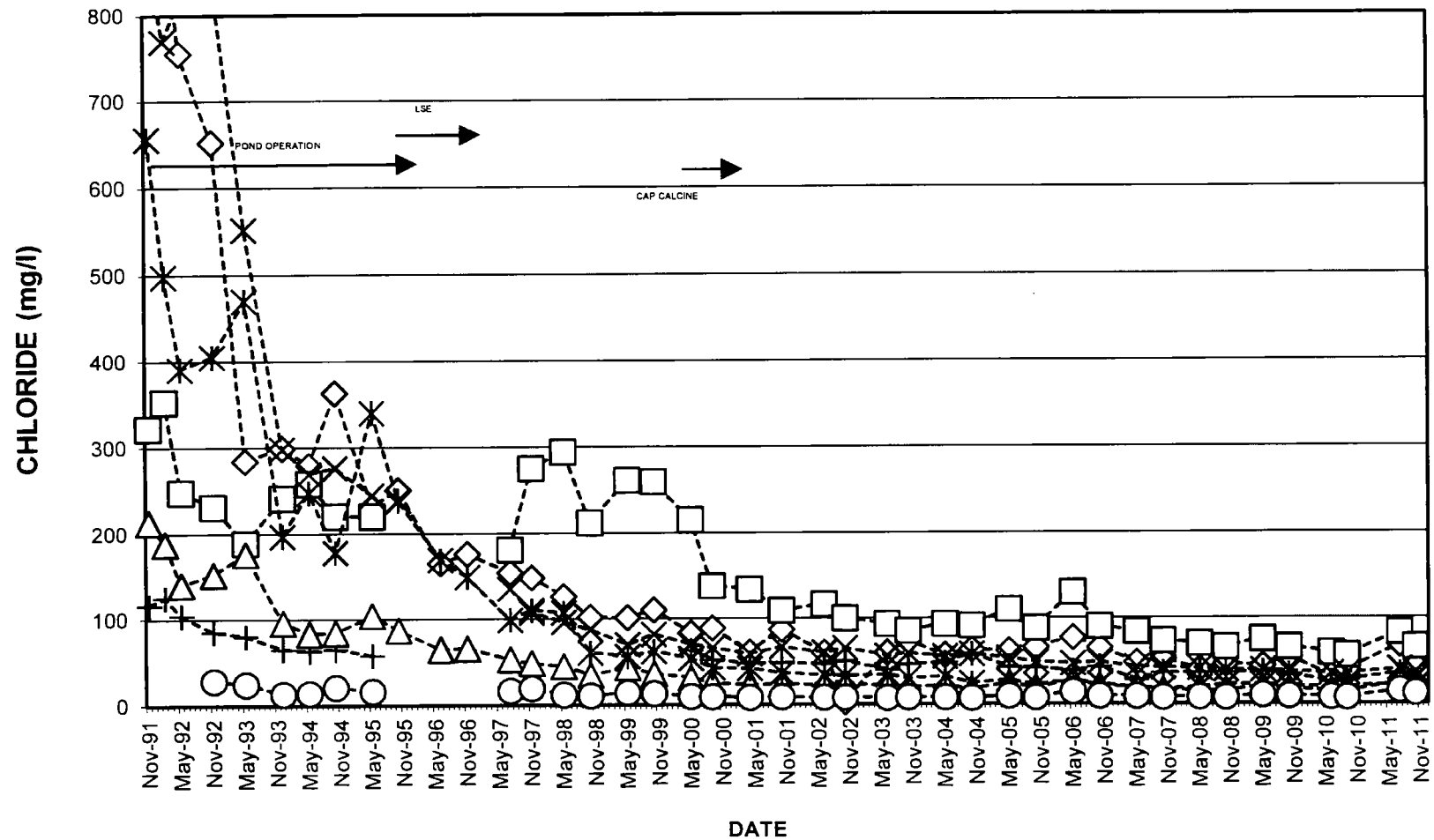
---◇--- KM-2

---□--- KM-3

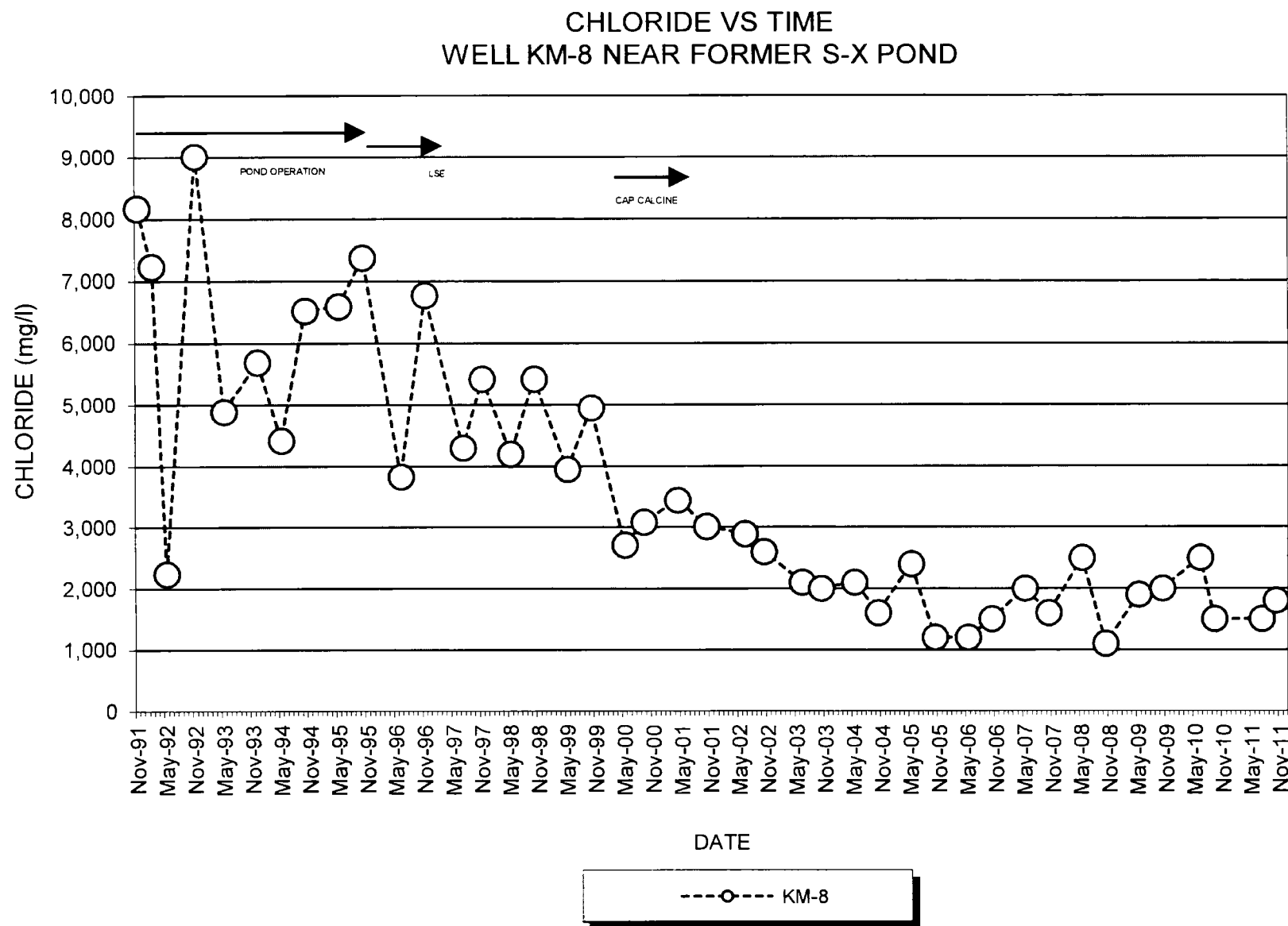
---△--- KM-4

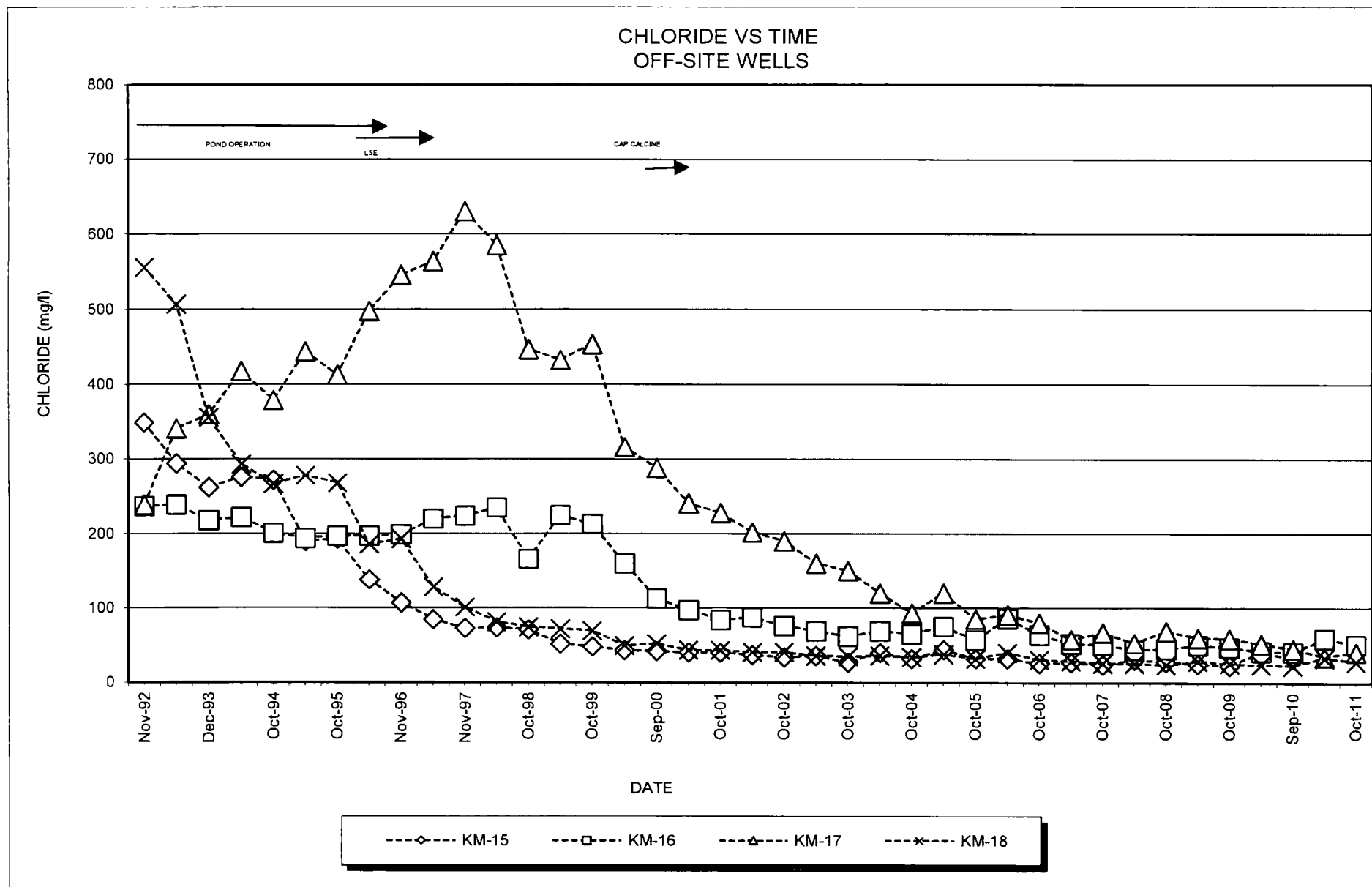
---x--- KM-11

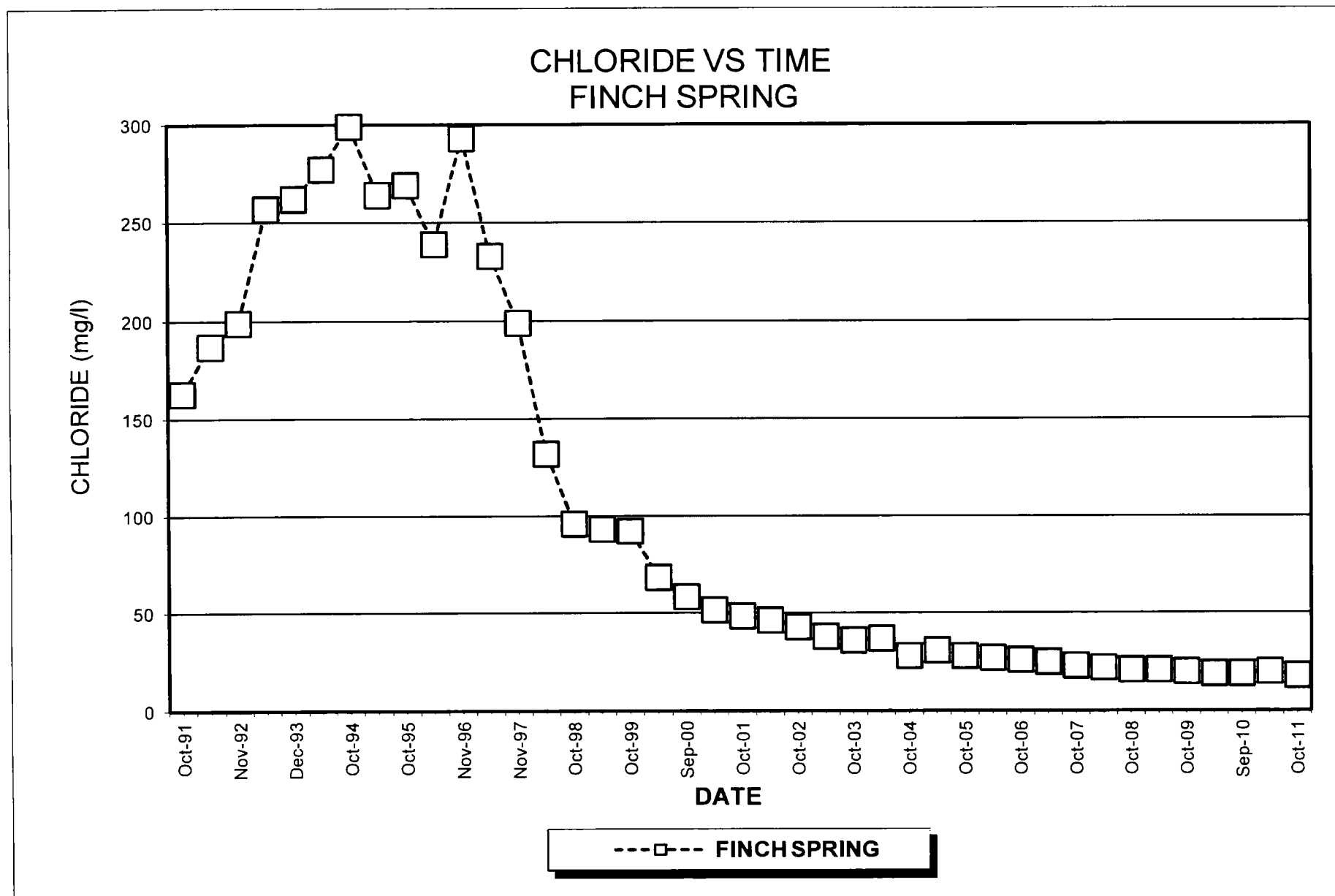
CHLORIDE VS TIME WELLS NEAR WEST SIDE OF FACILITY OR NEAR FORMER S-X POND

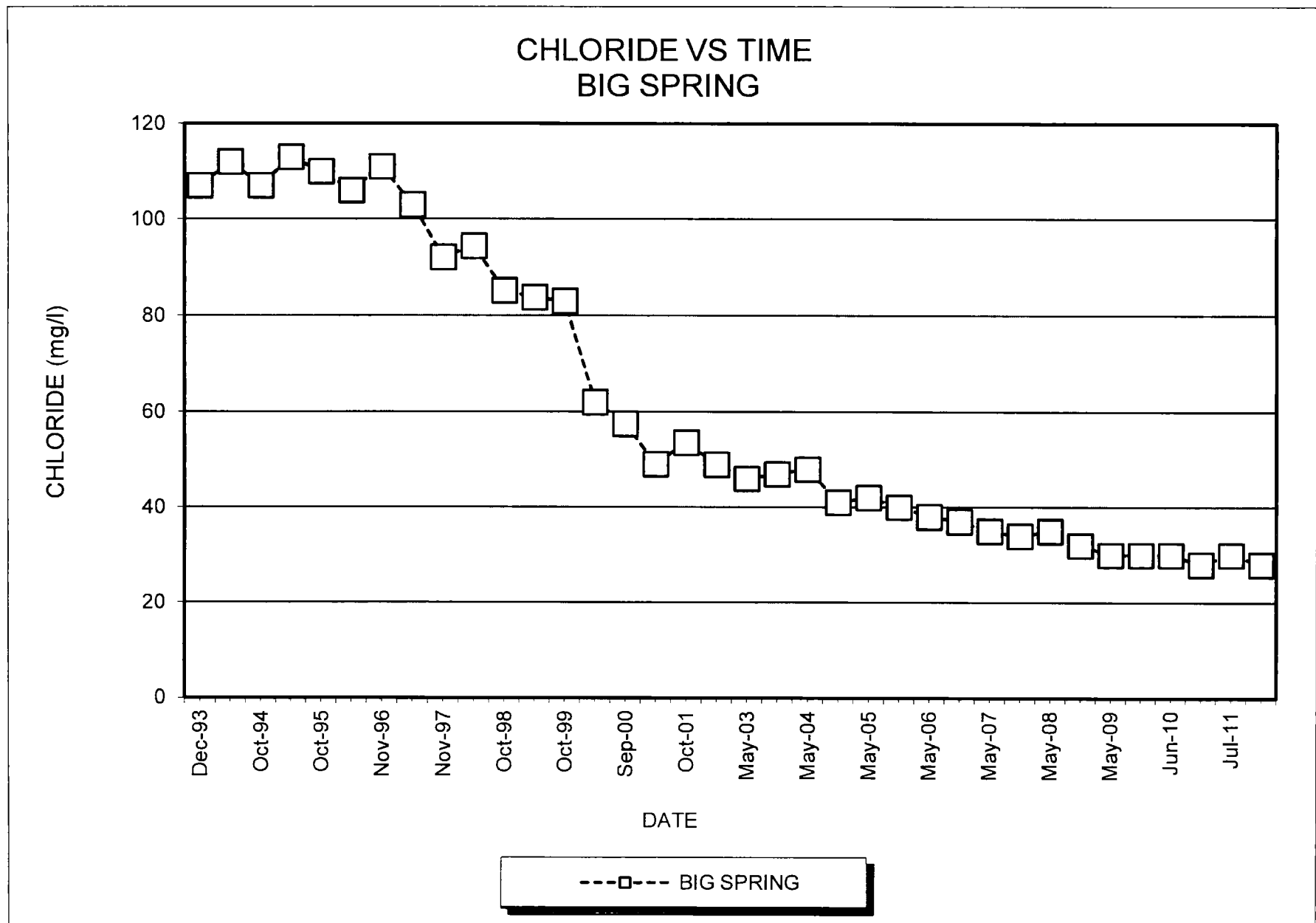


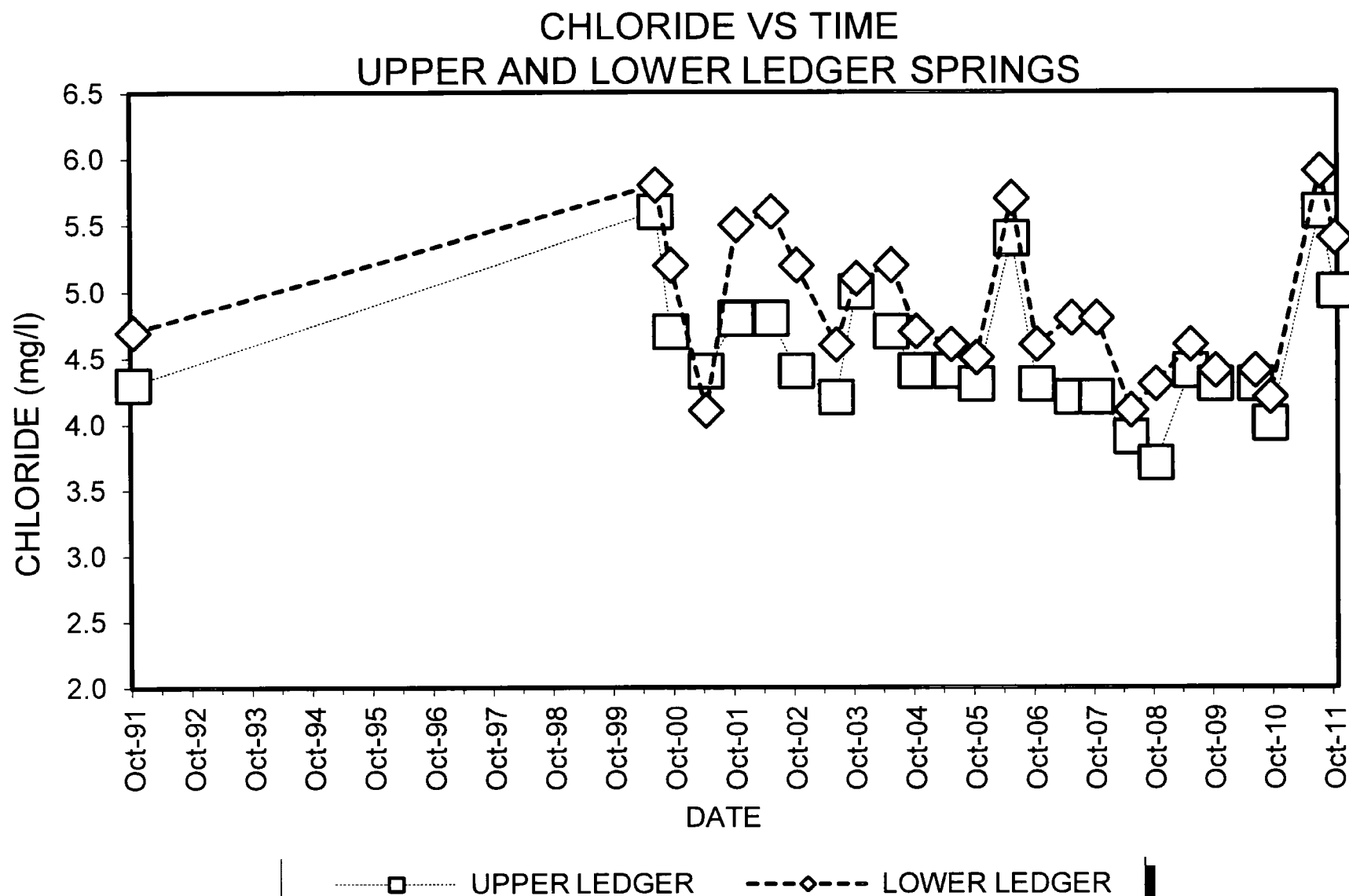
---◇--- KM-5 ---□--- KM-6 ---+--- KM-7 ---△--- KM-9 ---×--- KM-12 ---*--- KM-13 ---○--- KM-19

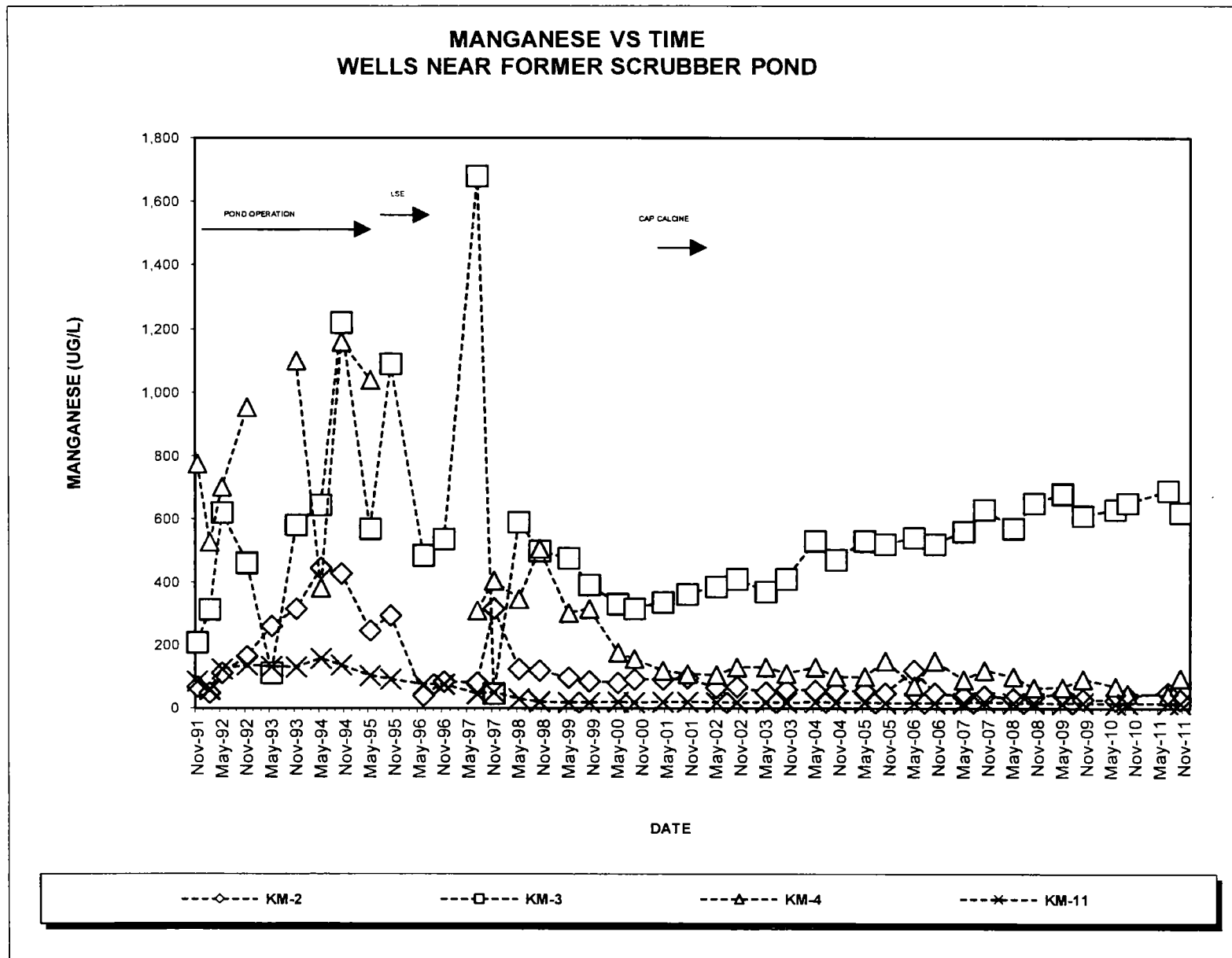








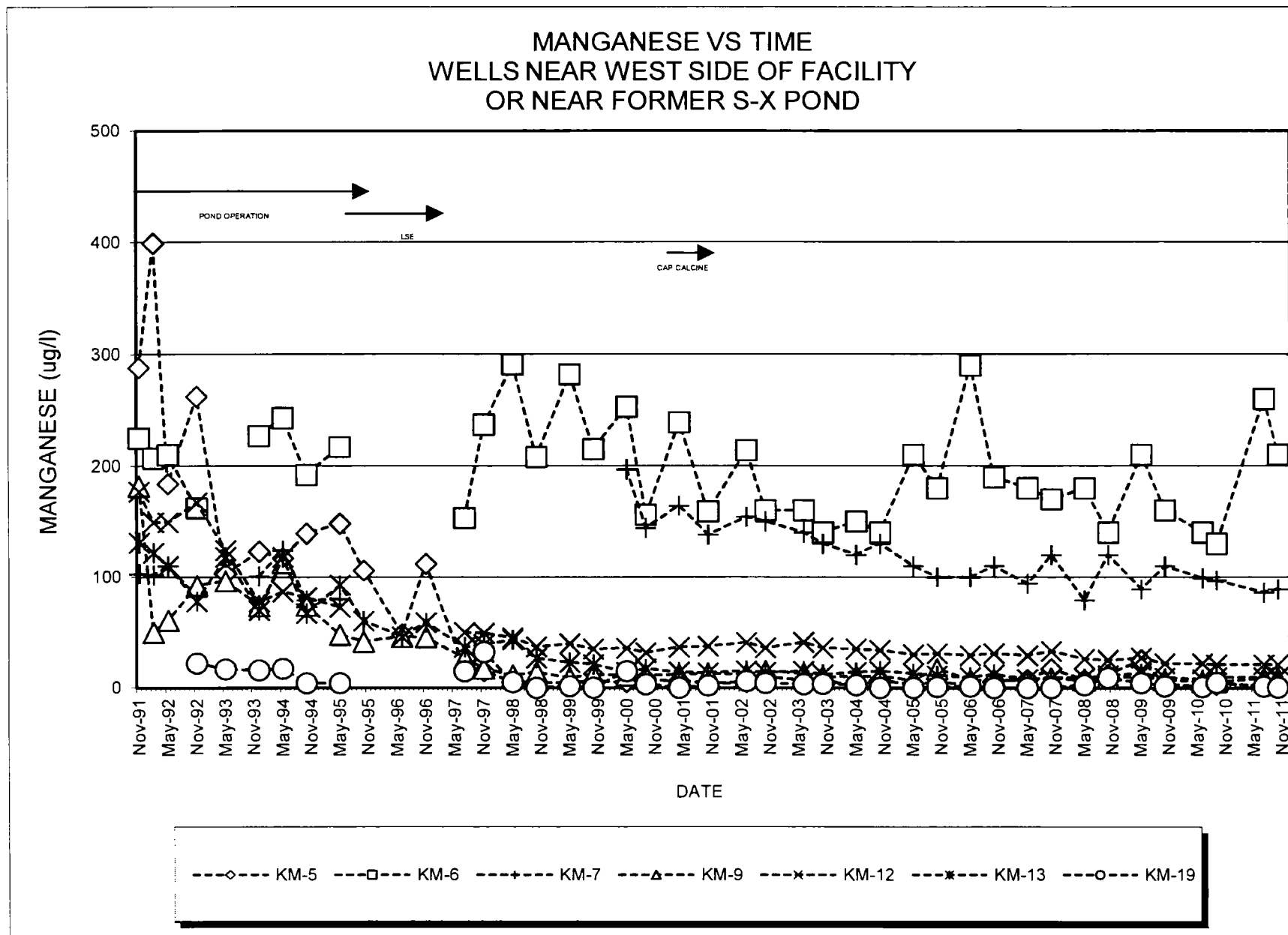




RBC FOR MANGANESE IS 180 ug/l

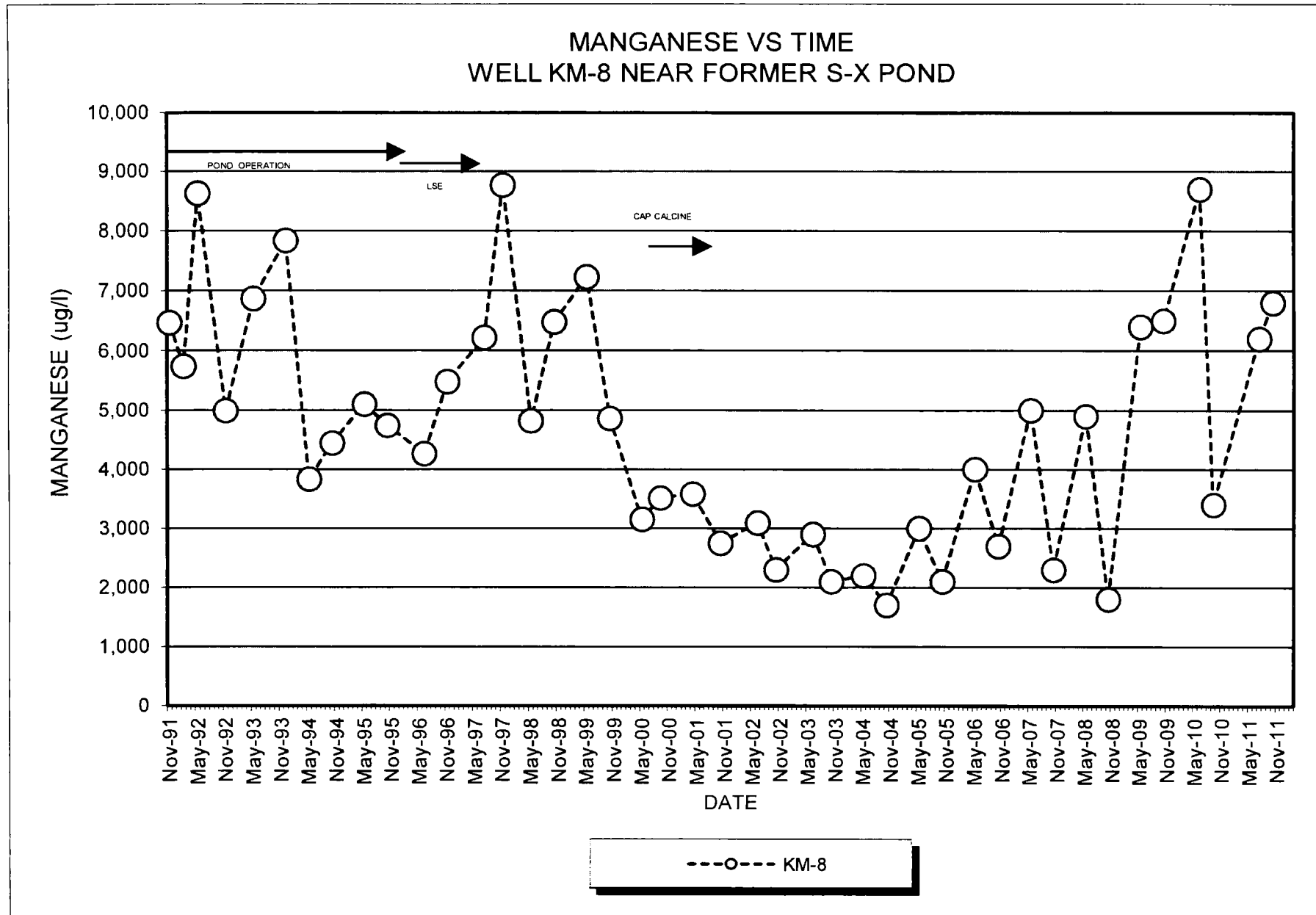
KM-2, KM-3, KM-11 ARE POC WELLS

VALUES LESS THAN DETECTION ARE PLOTTED AT DETECTION LIMIT

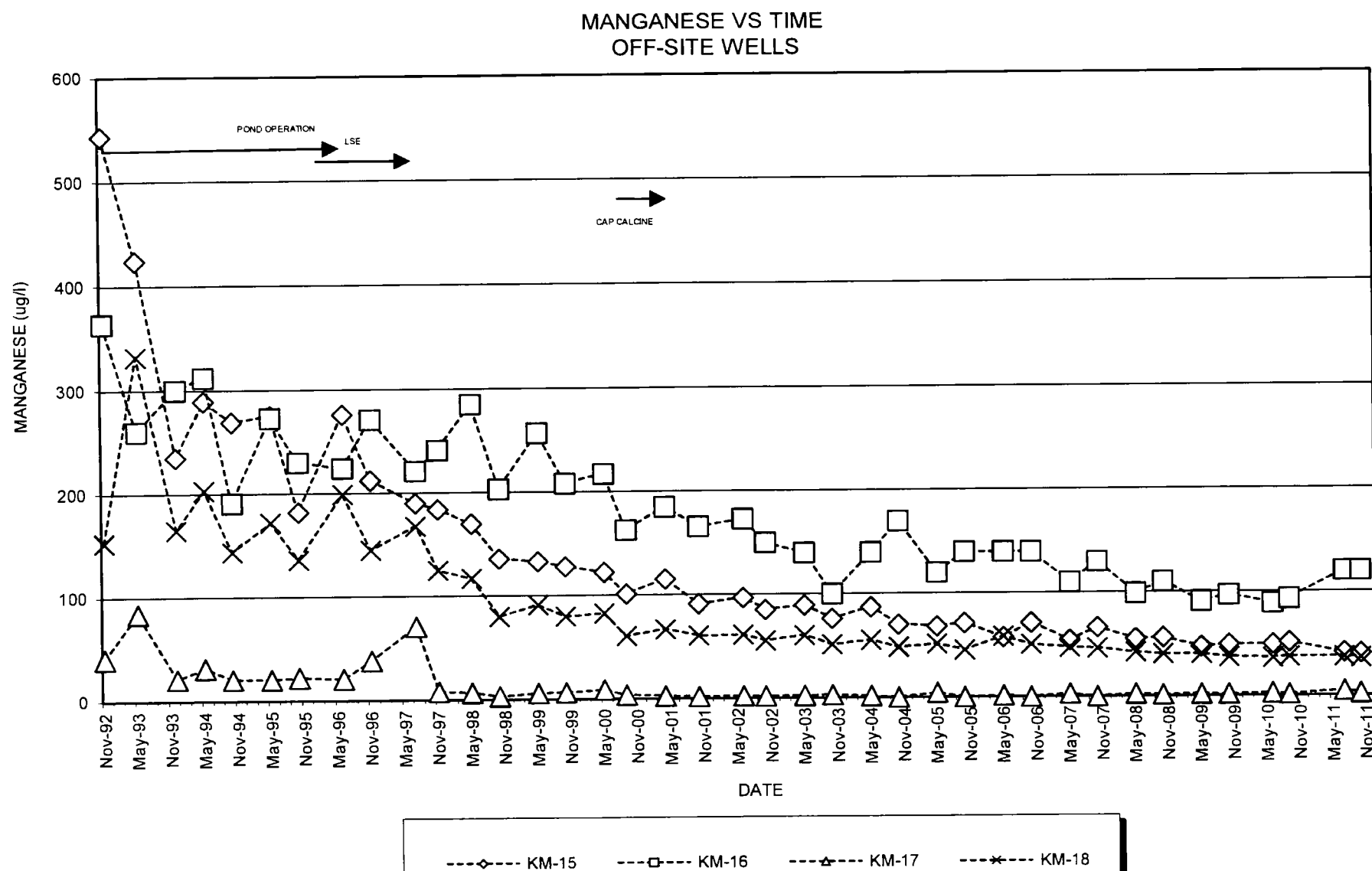


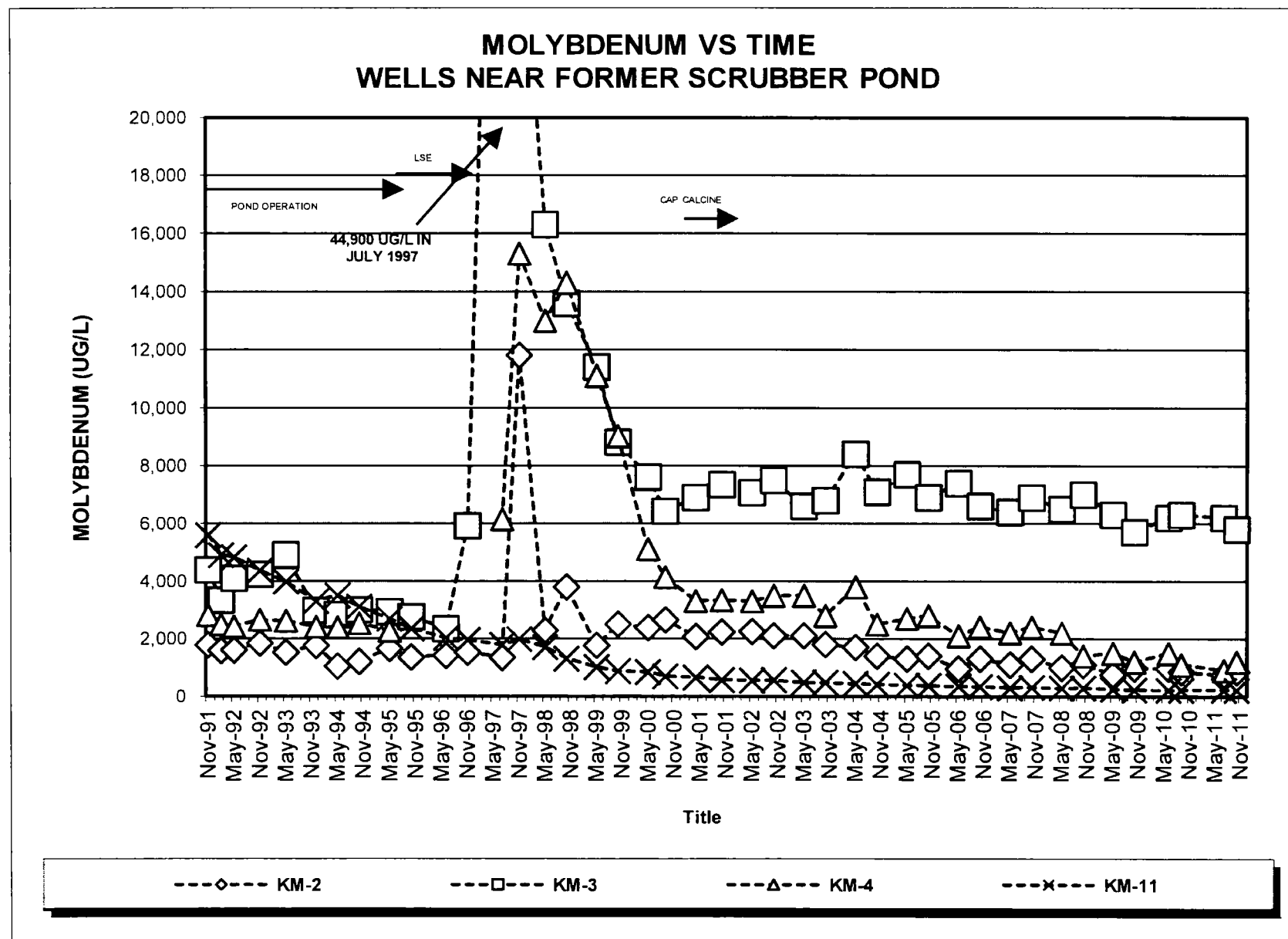
RBC FOR MANGANESE IS 180 ug/l

KM-5, KM-9, KM-12, KM-13, KM-19 ARE POC WELLS

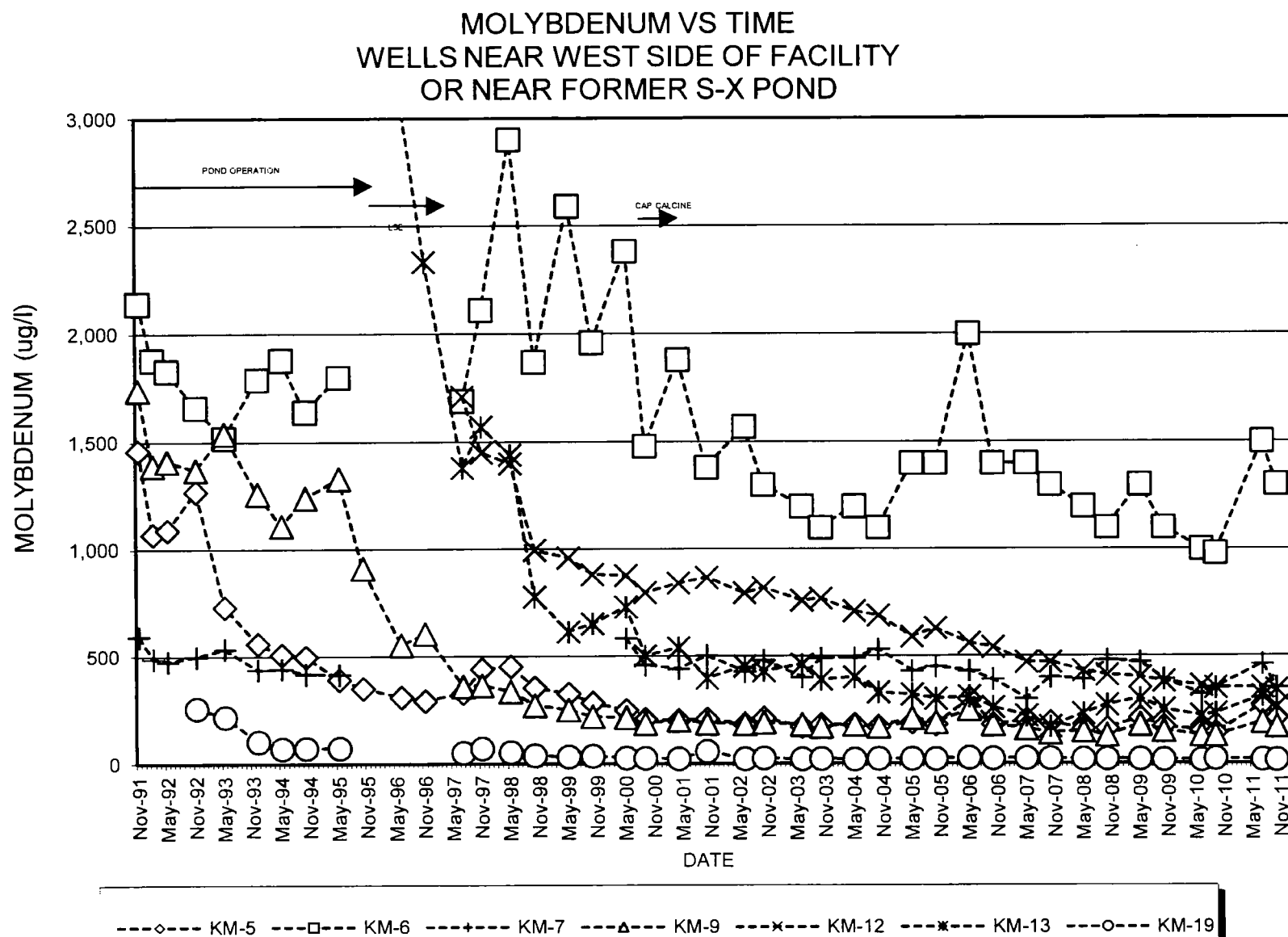


RBC FOR MANGANESE IS 180 ug/l
KM-8 IS A POC WELL

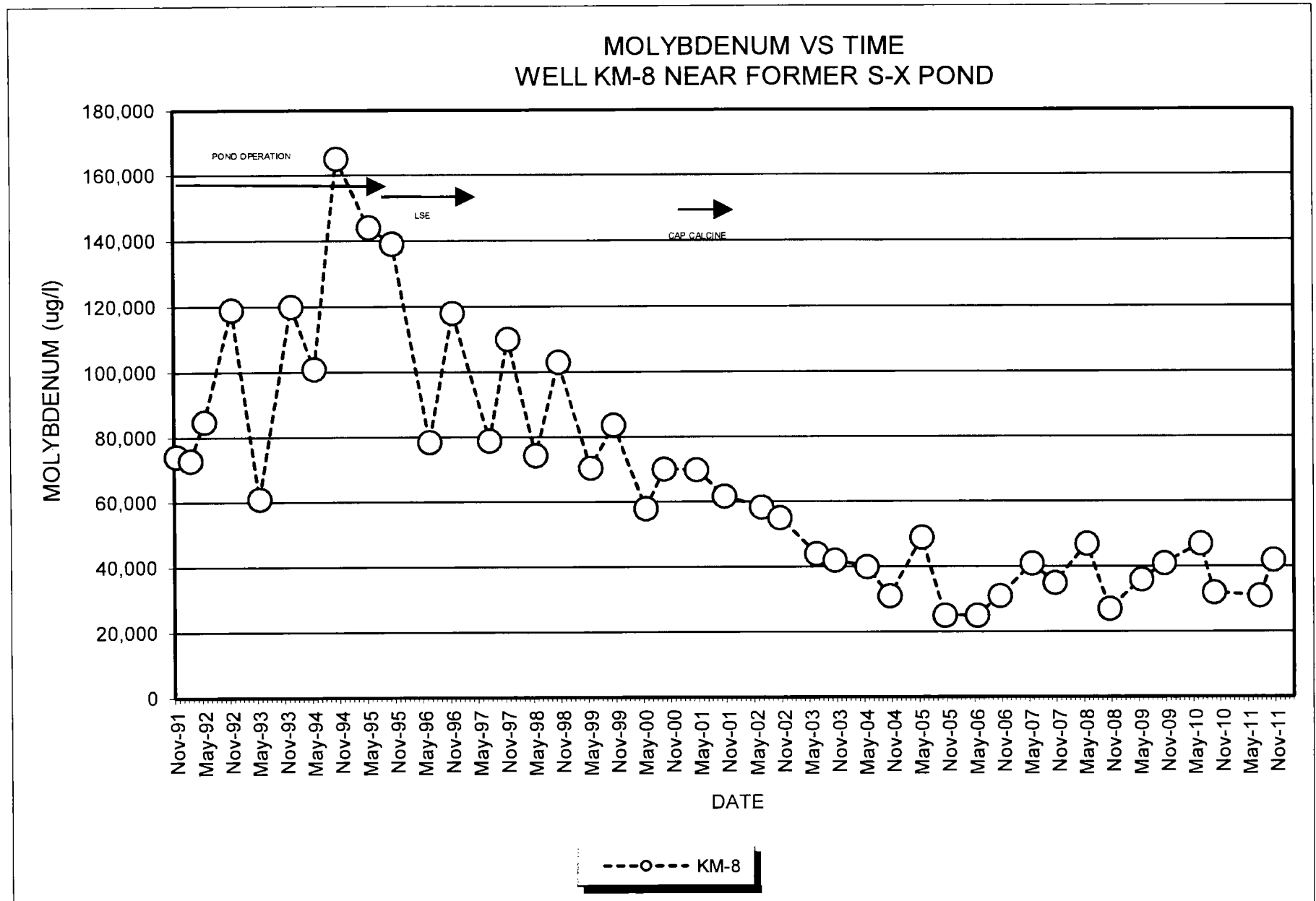




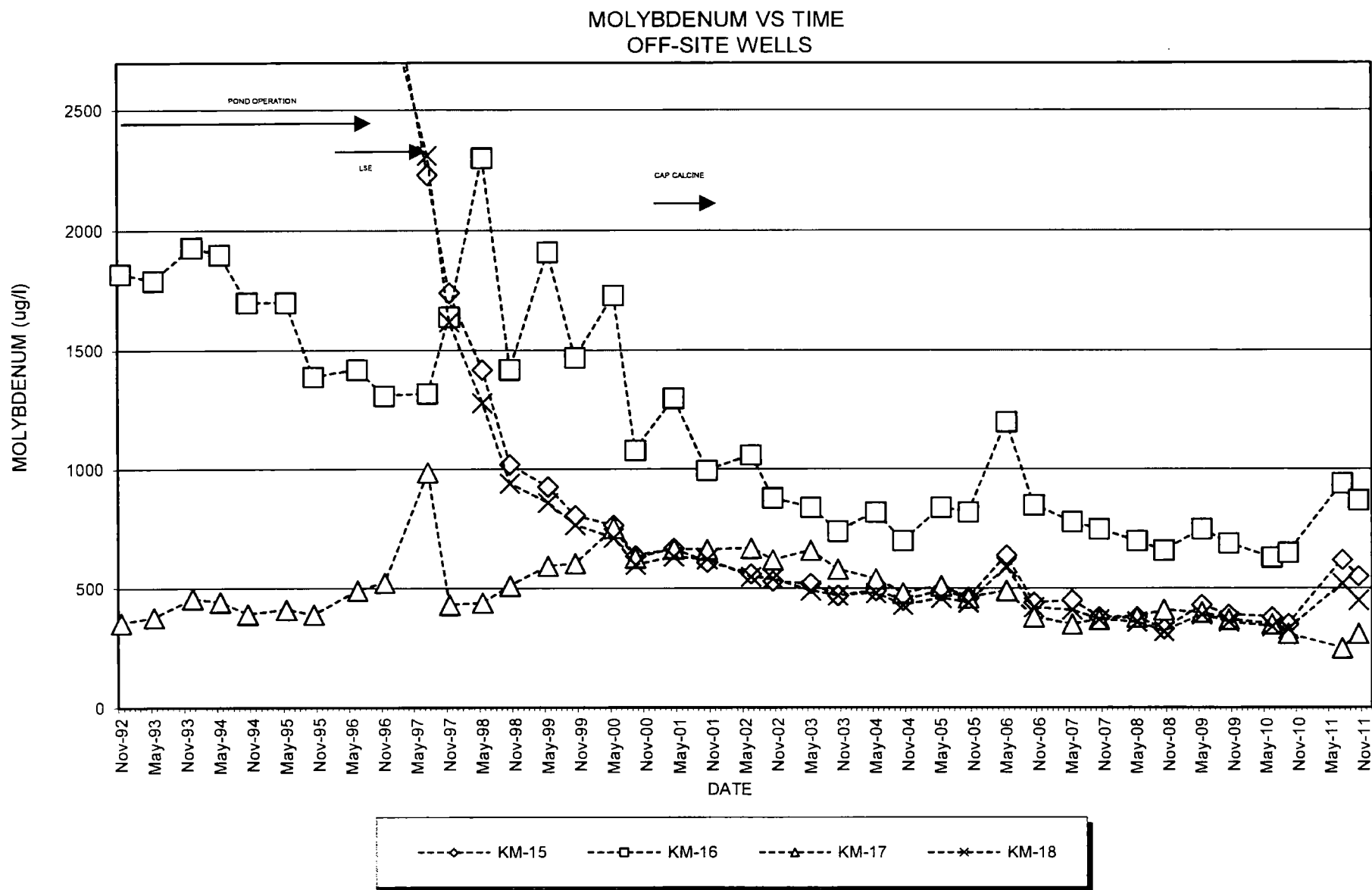
RBC FOR Molybdenum IS 180 ug/l
KM-2, KM-3, KM-11 ARE POC WELLS

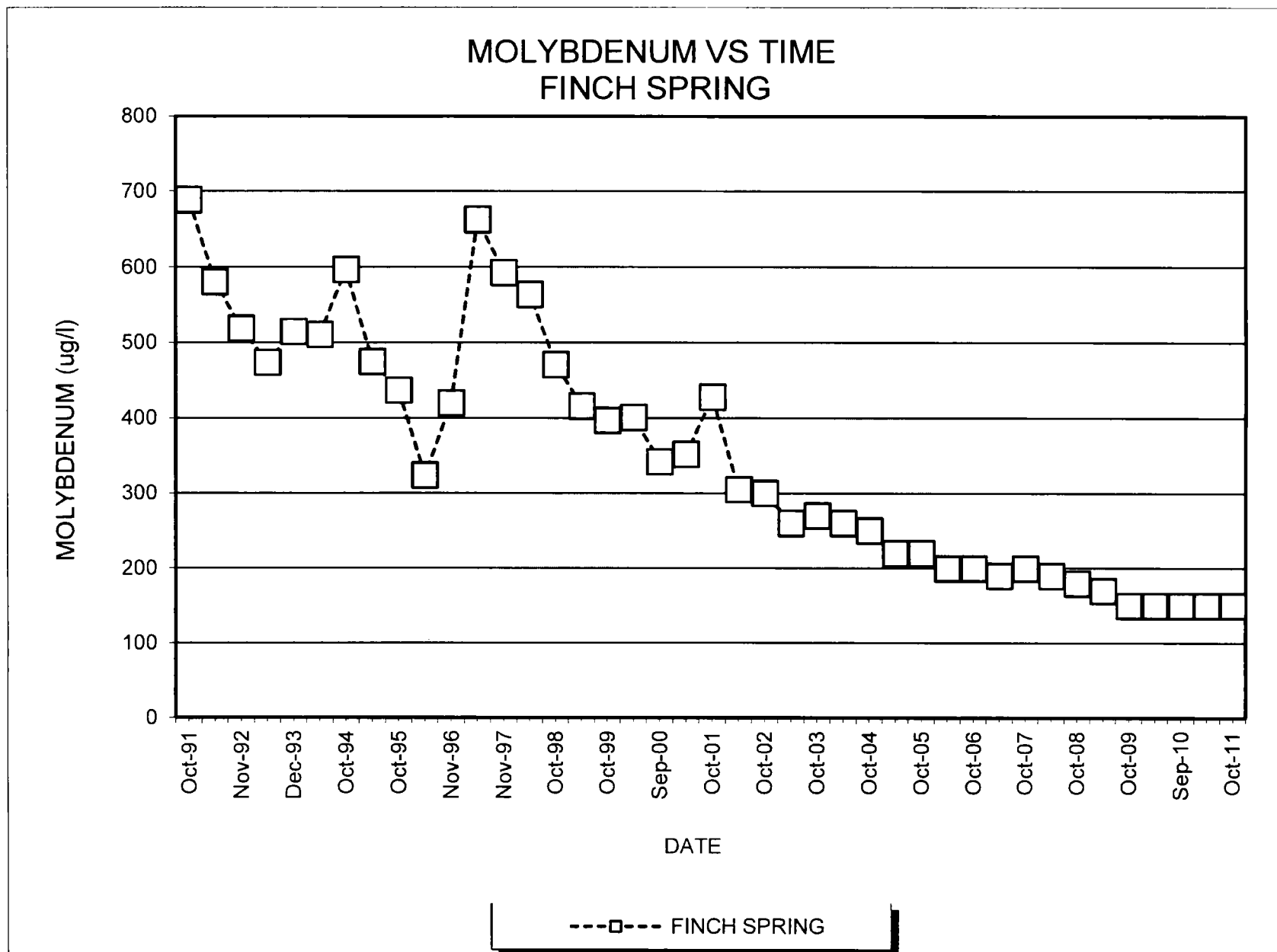


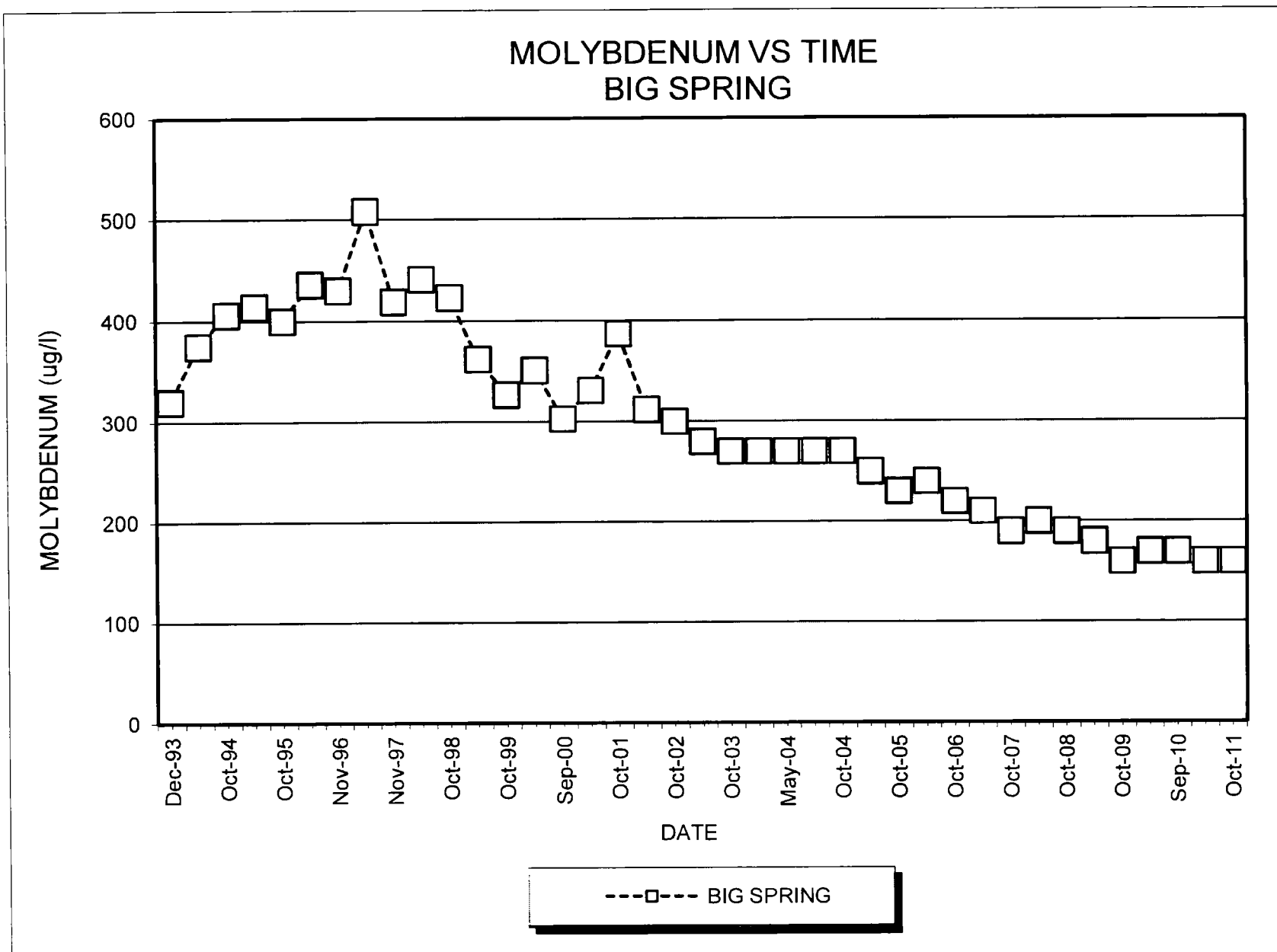
RBC FOR MOLYBDENUM IS 180 ug/l
KM-5, KM-9, KM-12, KM-13, KM-19 ARE POC WELLS

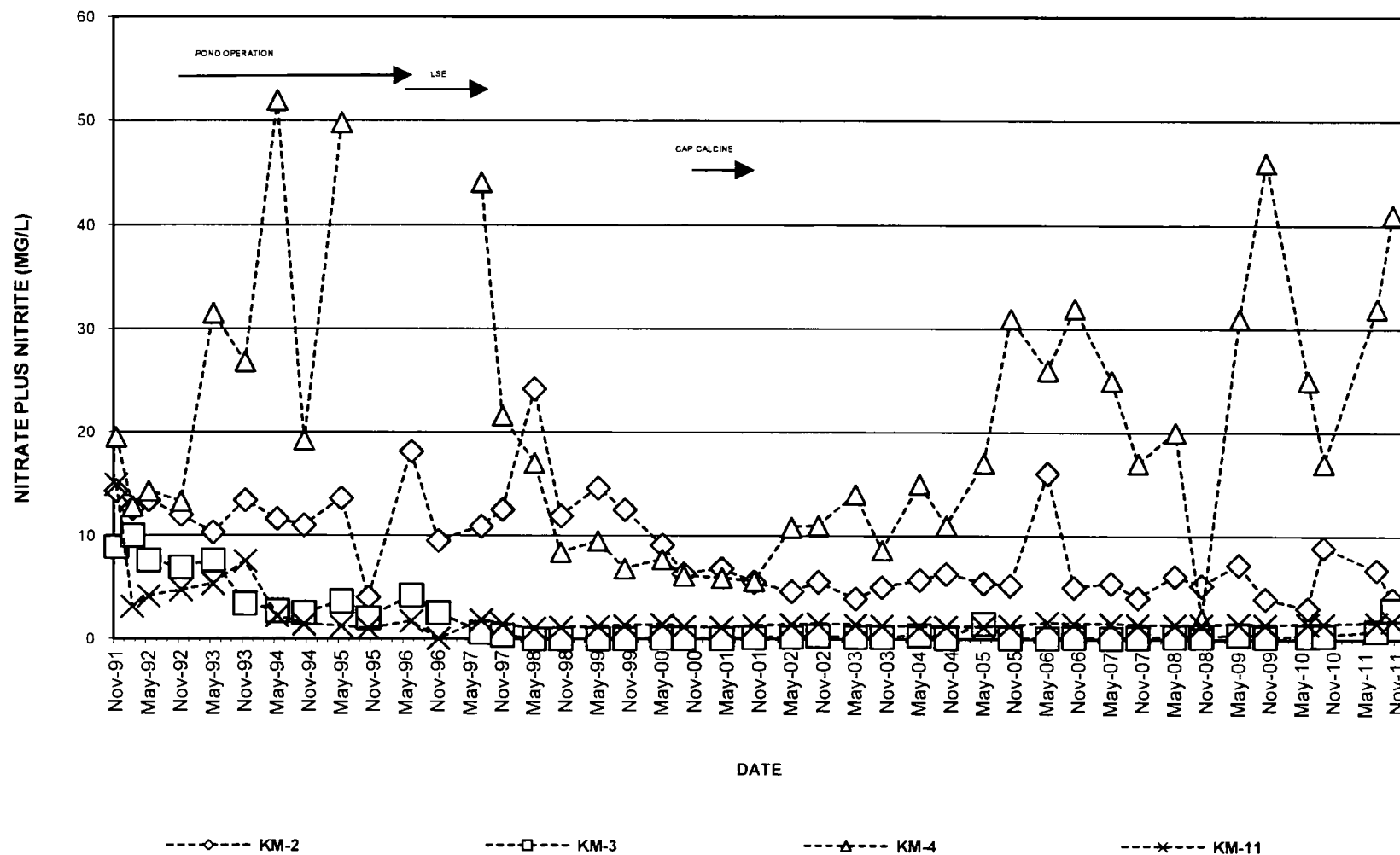


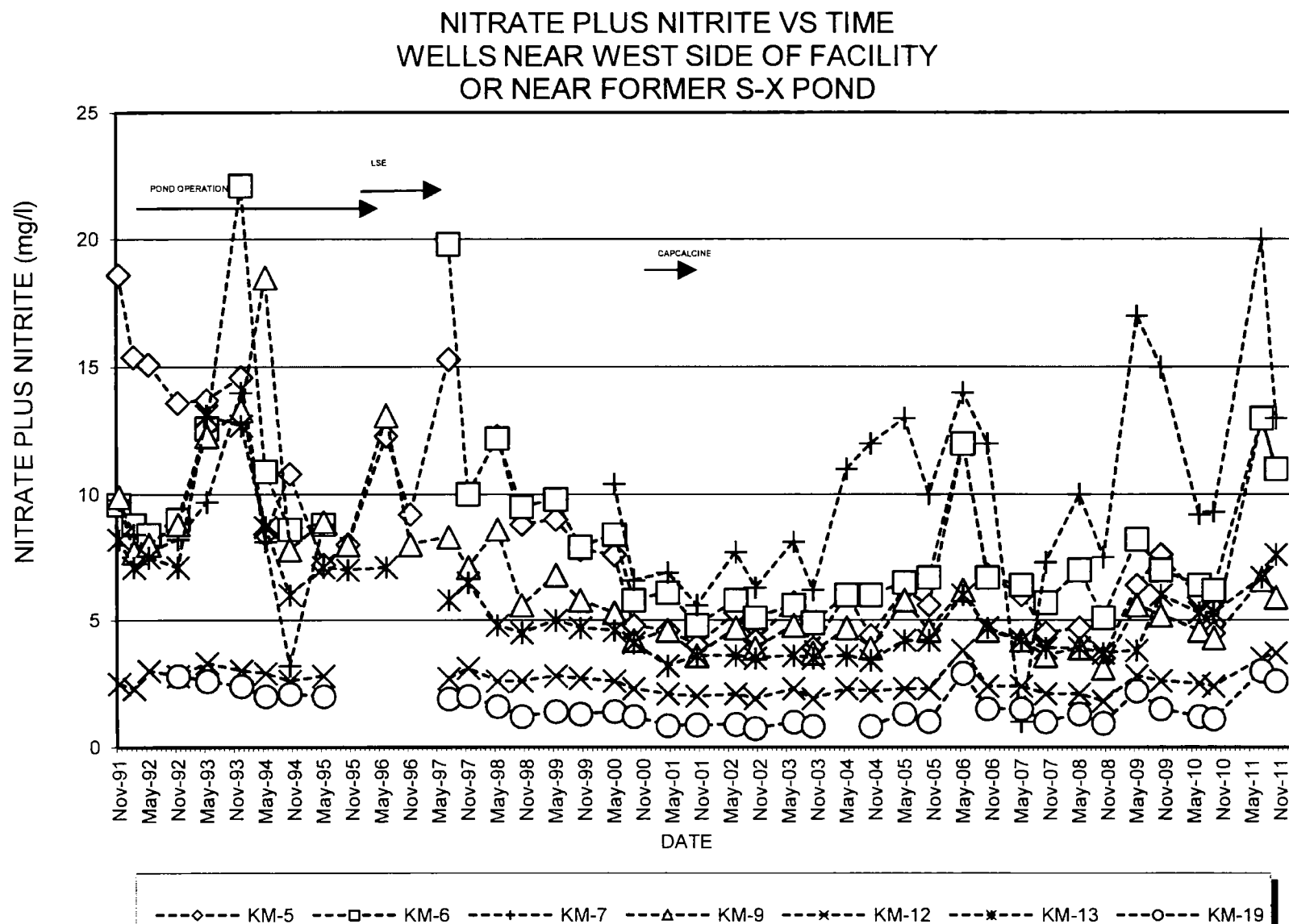
RBC FOR MOLYBDENUM IS 180 ug/l
KM-8 IS A POC WELL

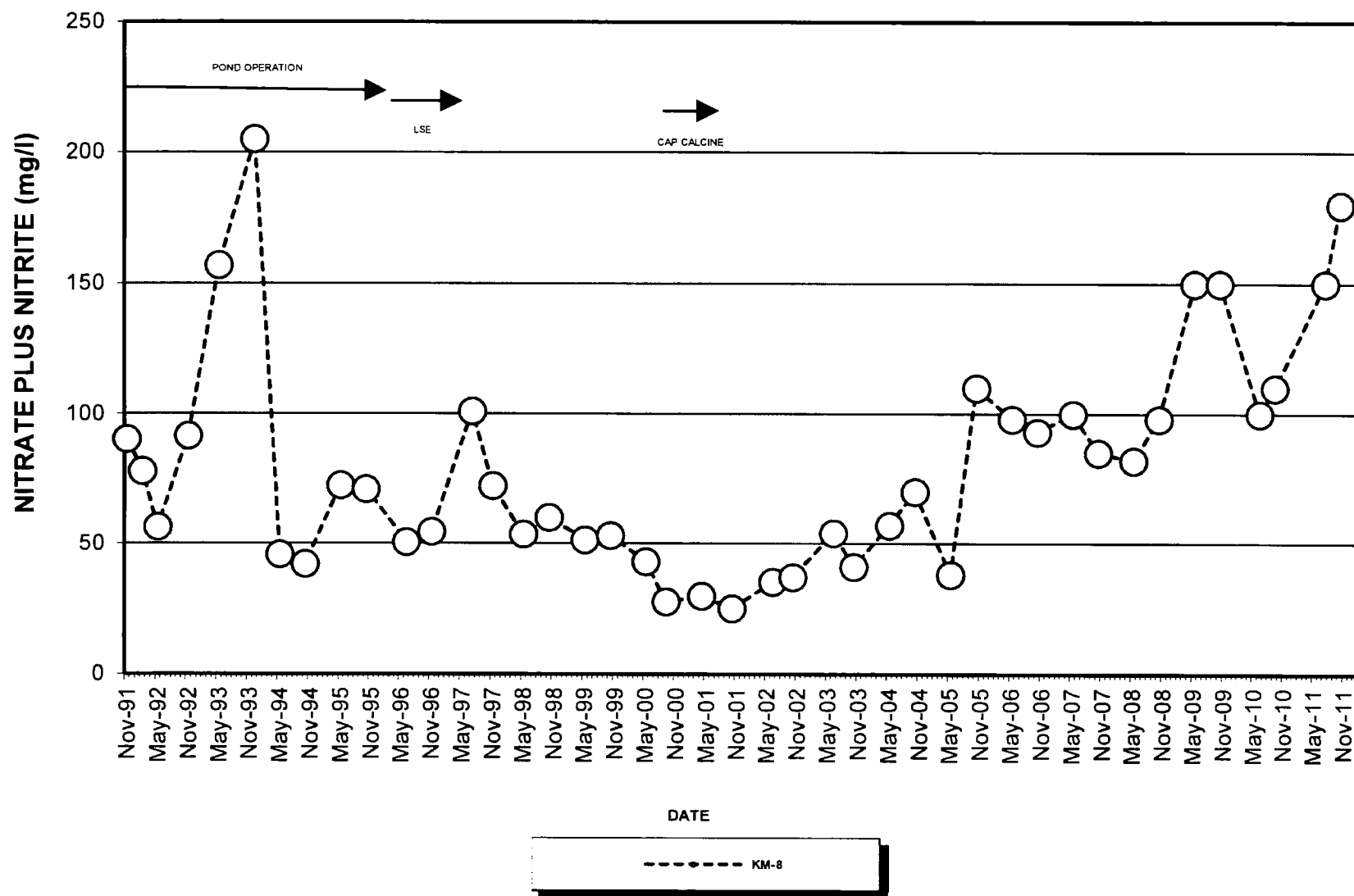


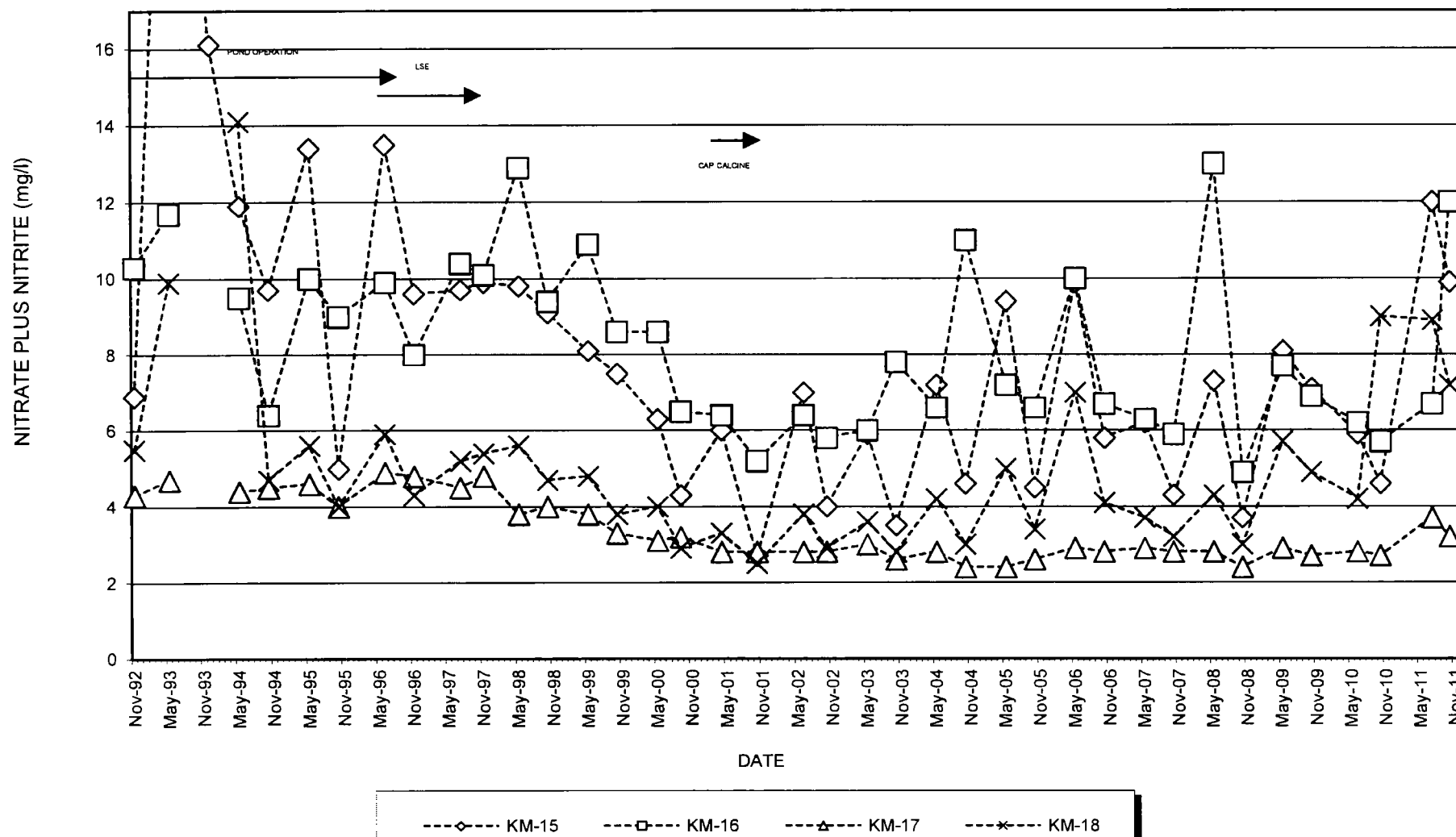


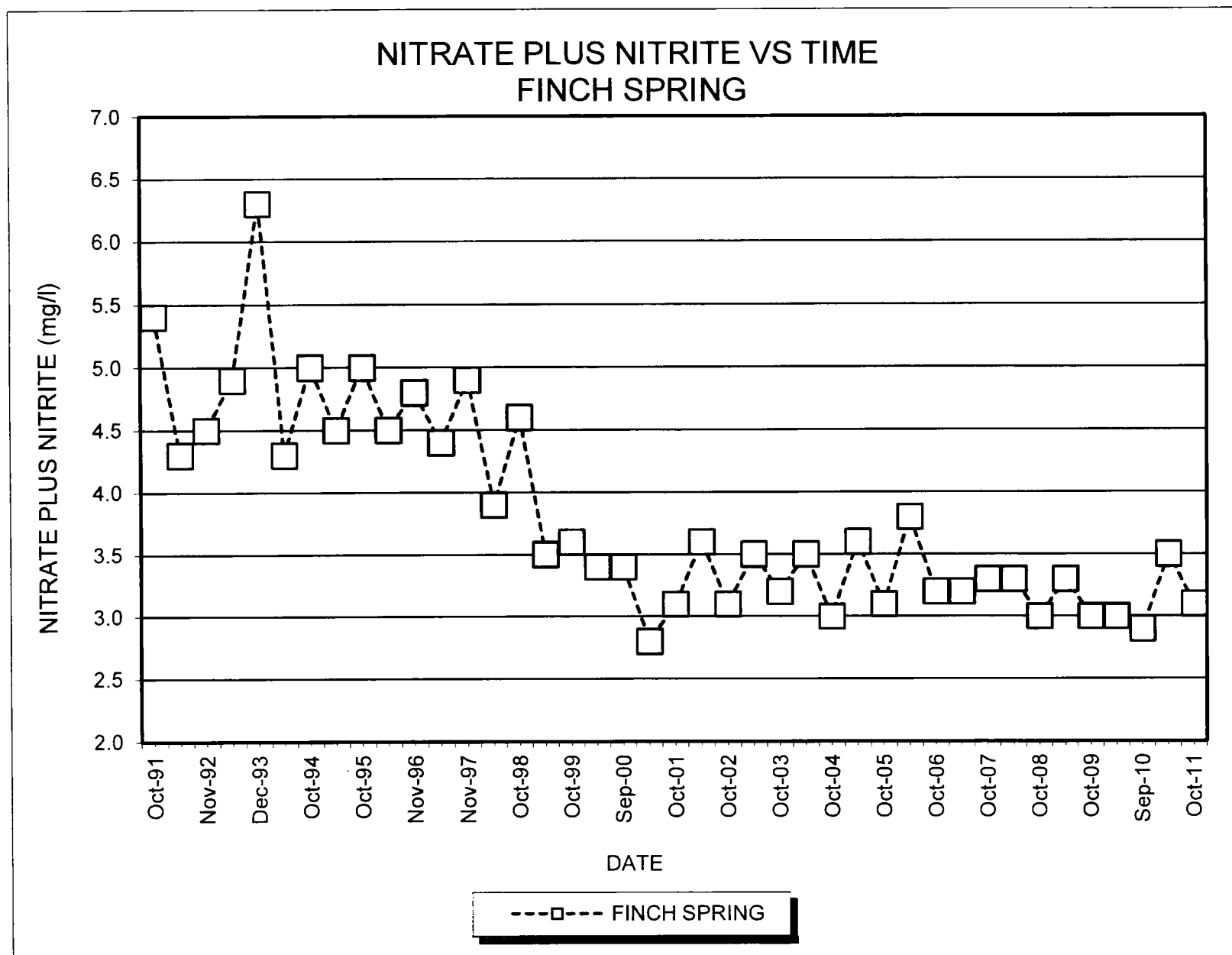


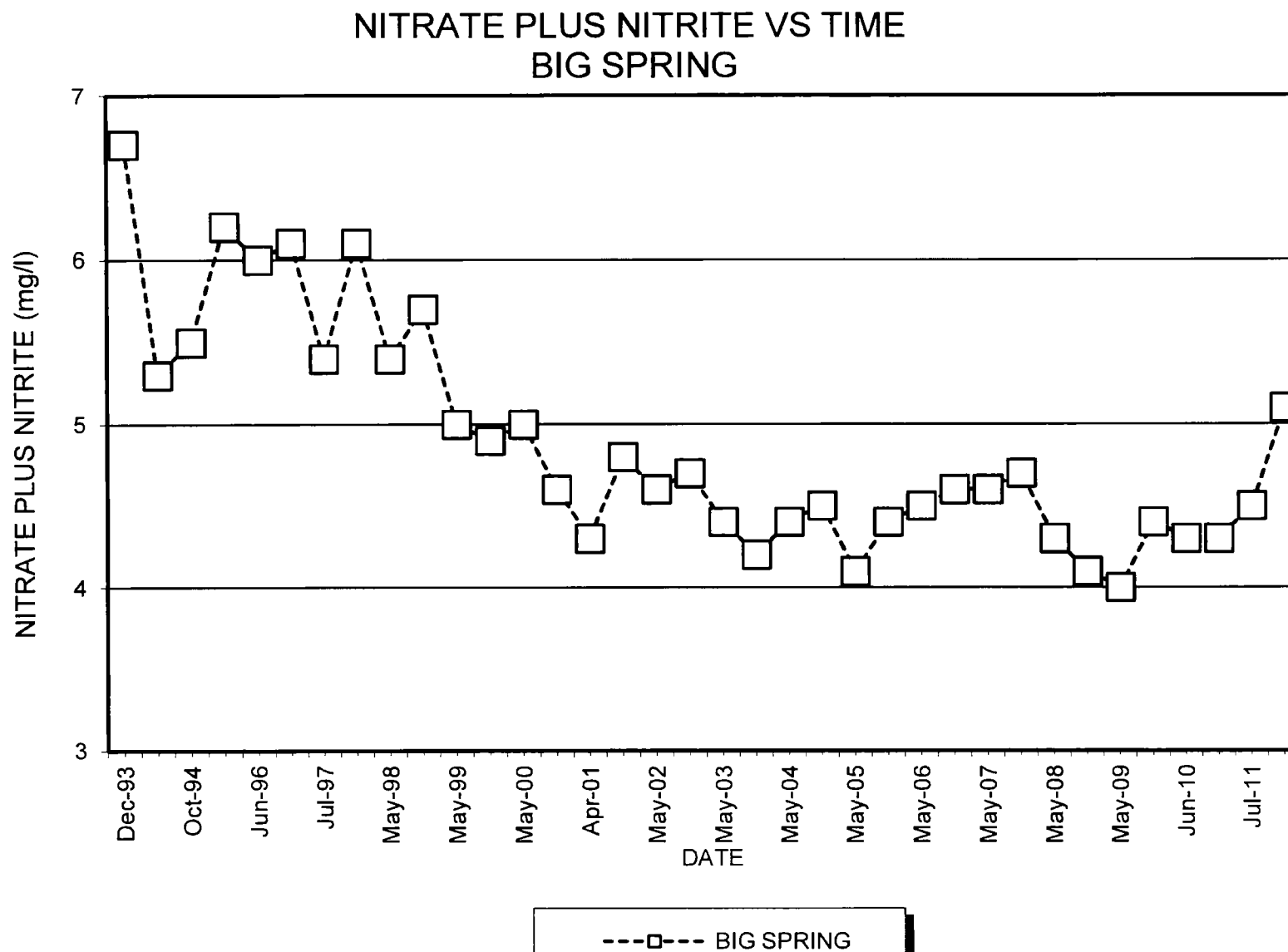
NITRATE PLUS NITRITE VS TIME
WELLS NEAR FORMER SCRUBBER POND



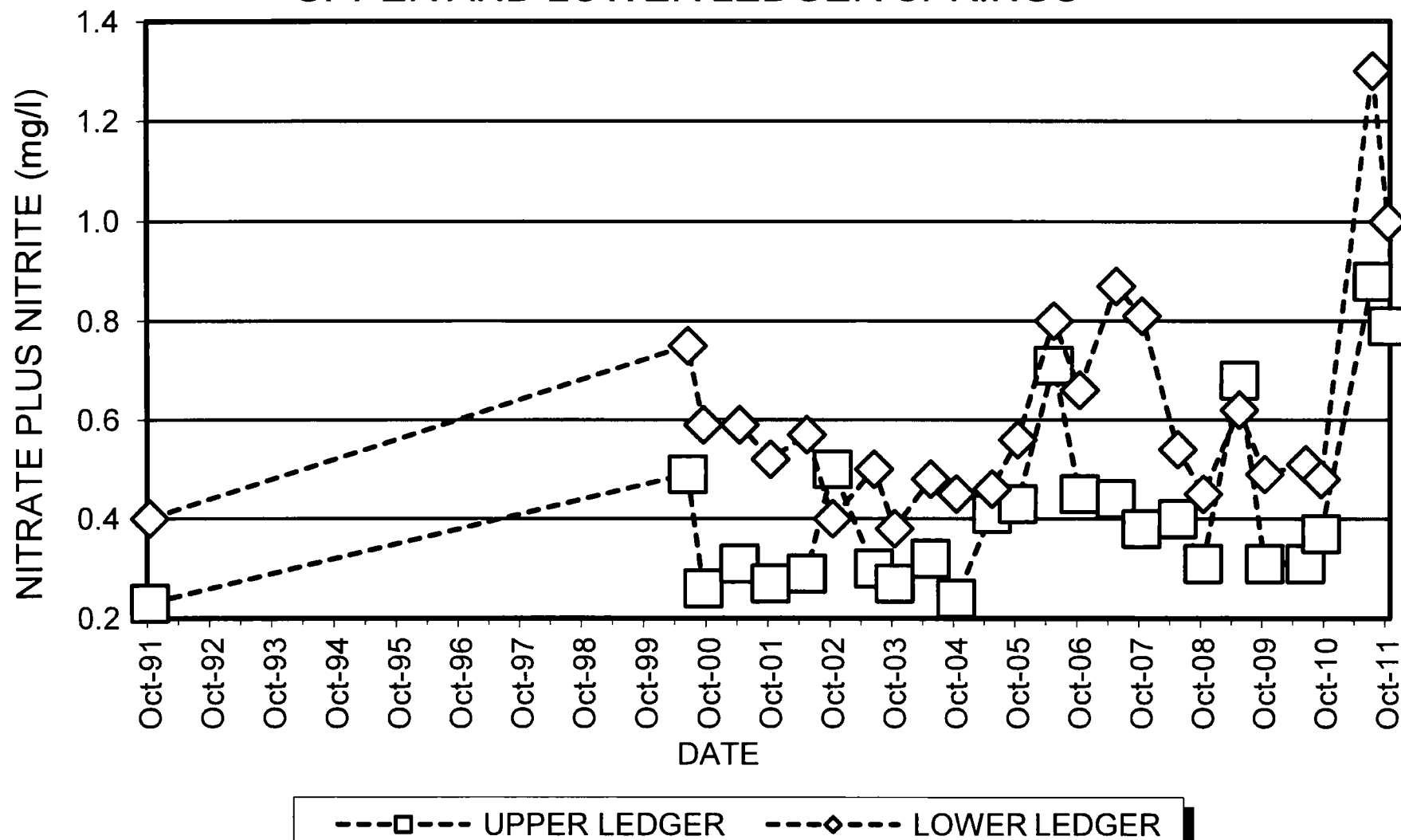
**NITRATE PLUS NITRITE VS TIME
WELL KM-8 NEAR FORMER S-X POND**

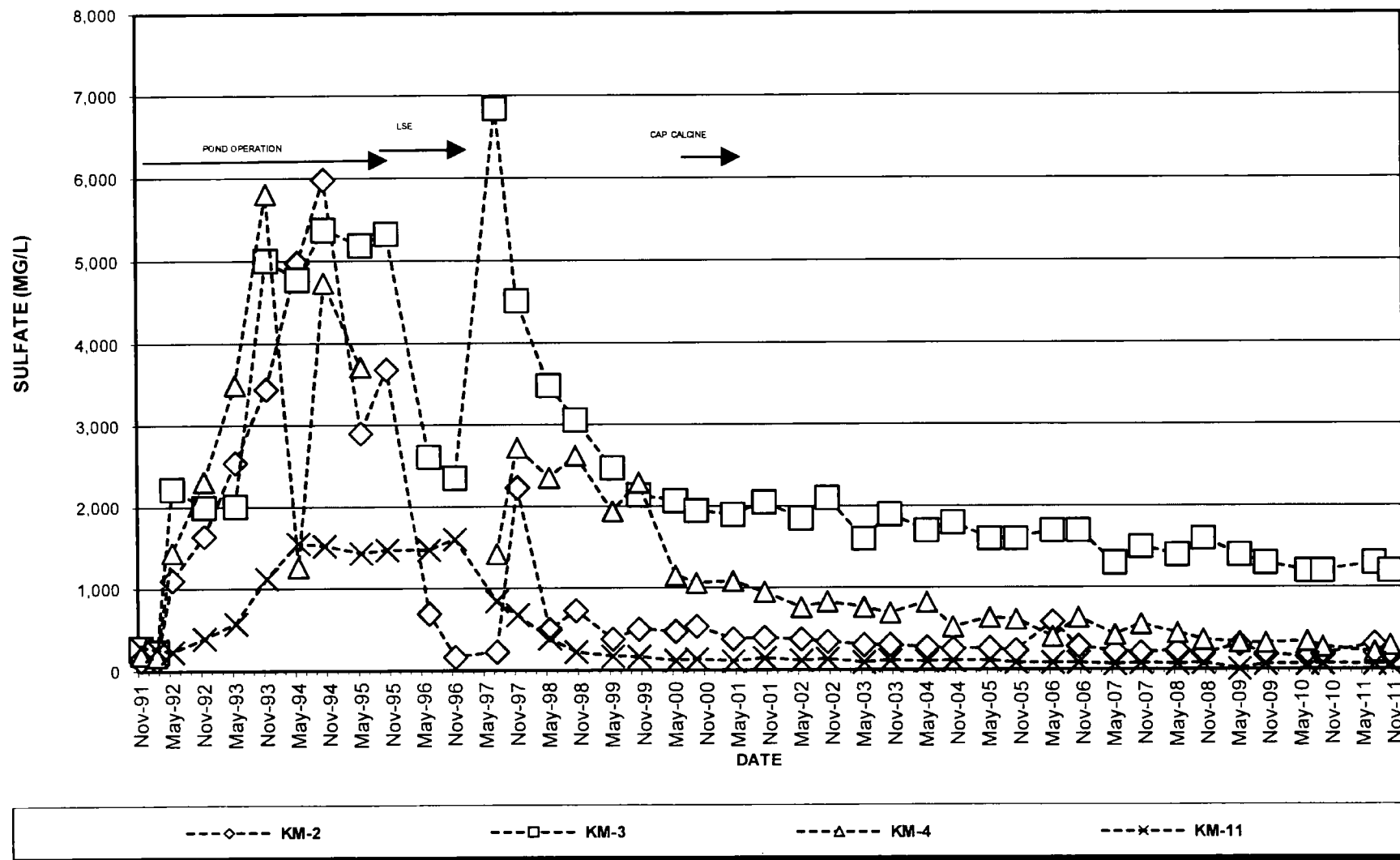
NITRATE PLUS NITRITE VS TIME
OFF-SITE WELLS

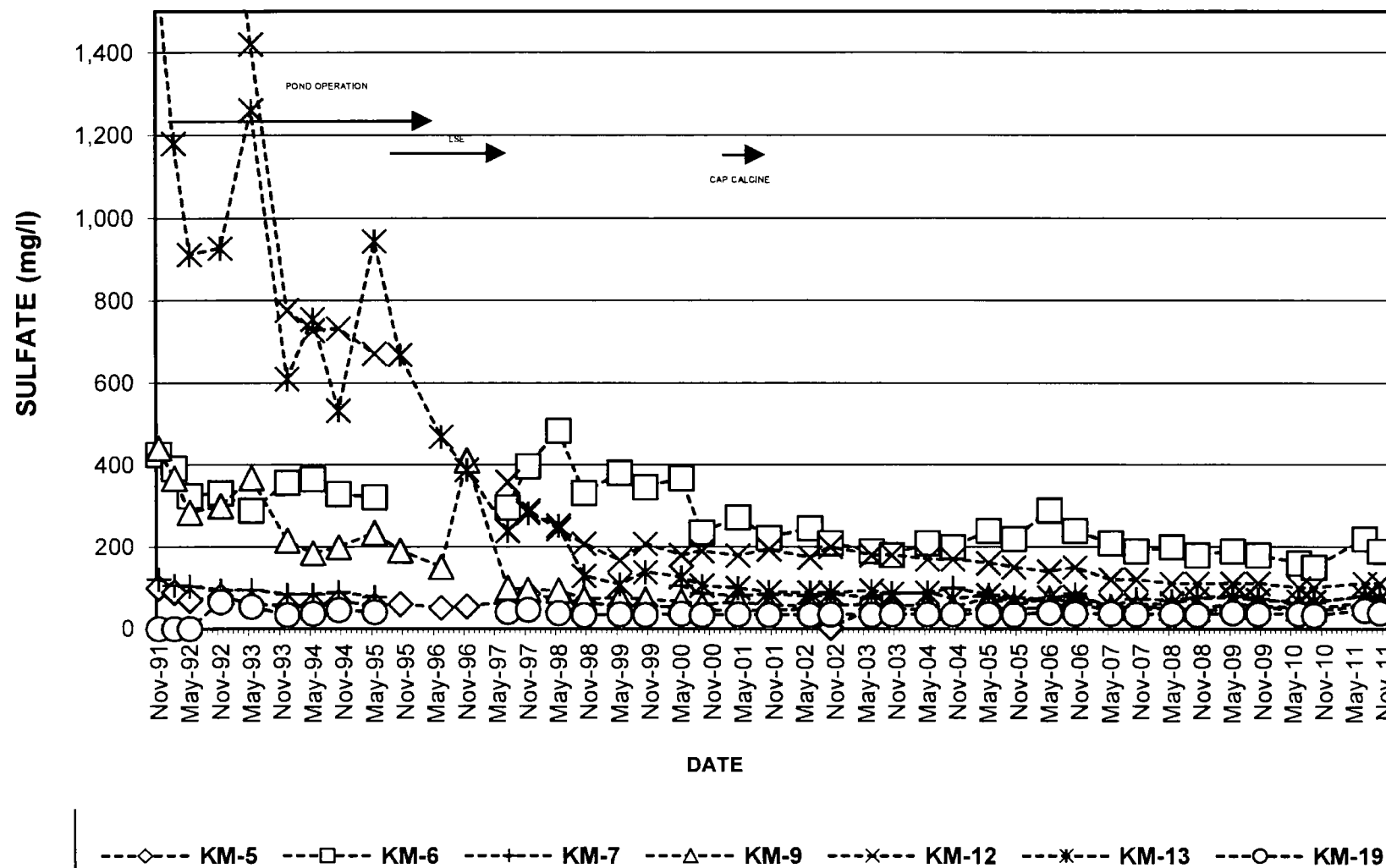


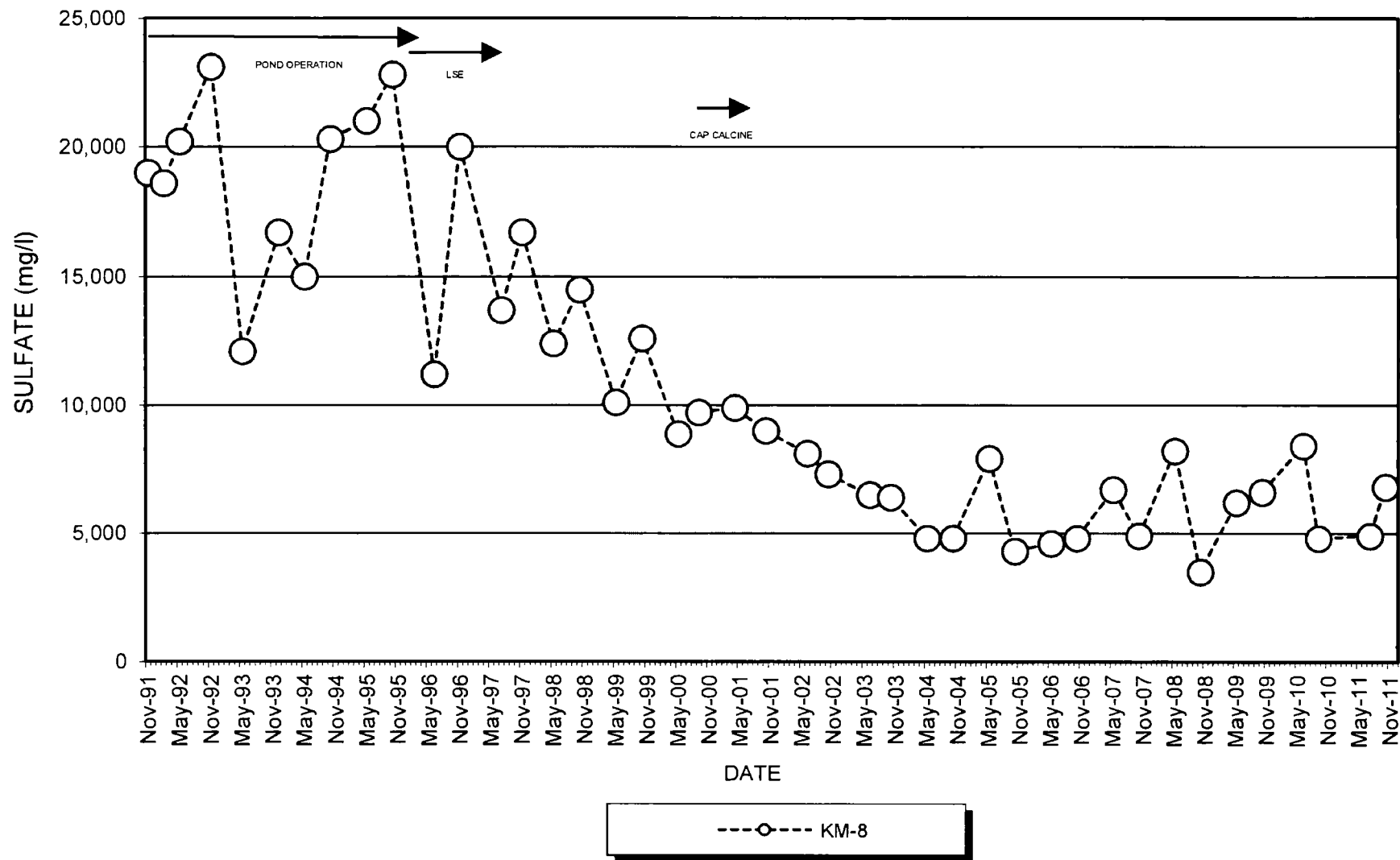


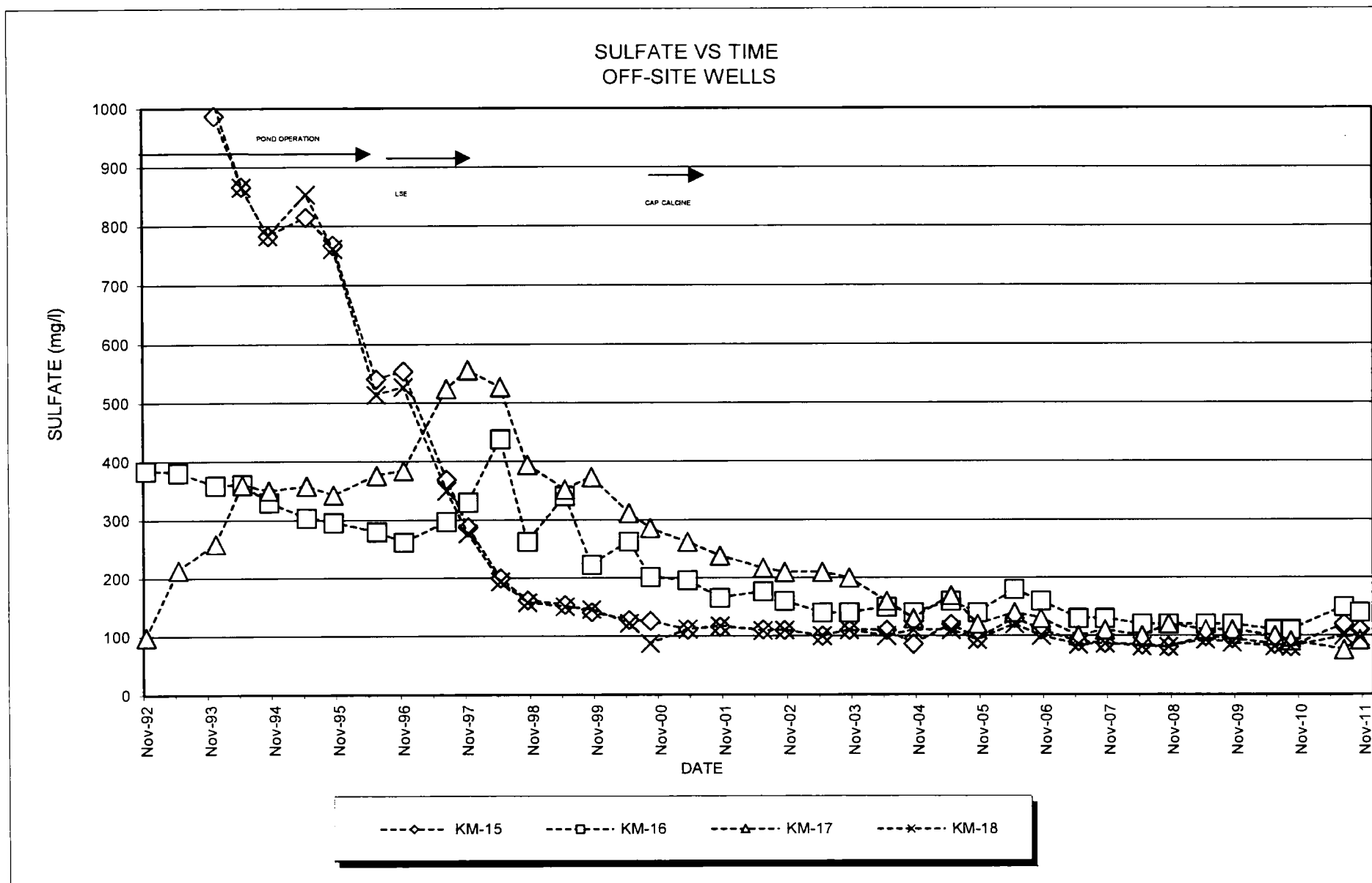
NITRATE PLUS NITRITE VS TIME UPPER AND LOWER LEDGER SPRINGS

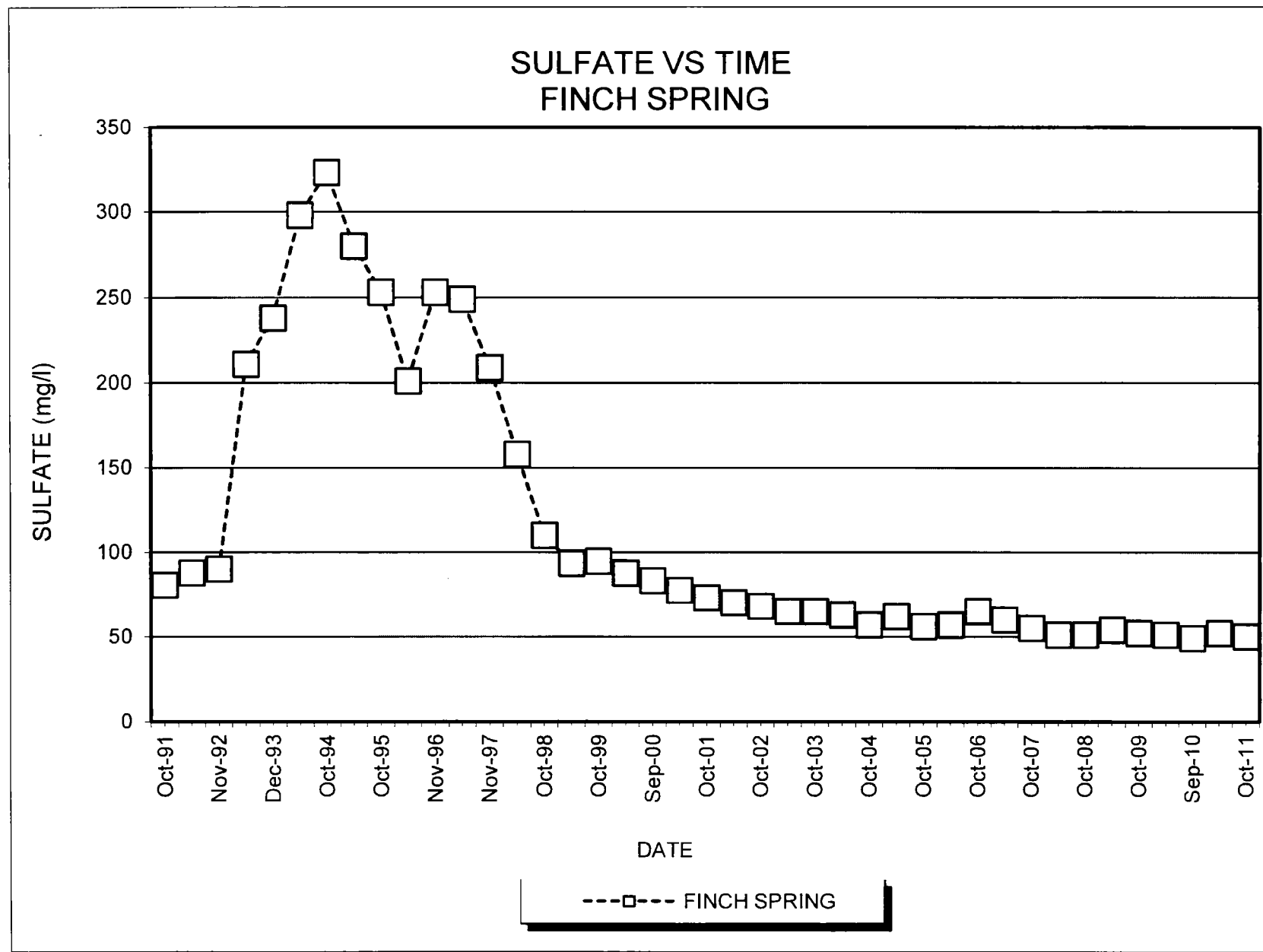


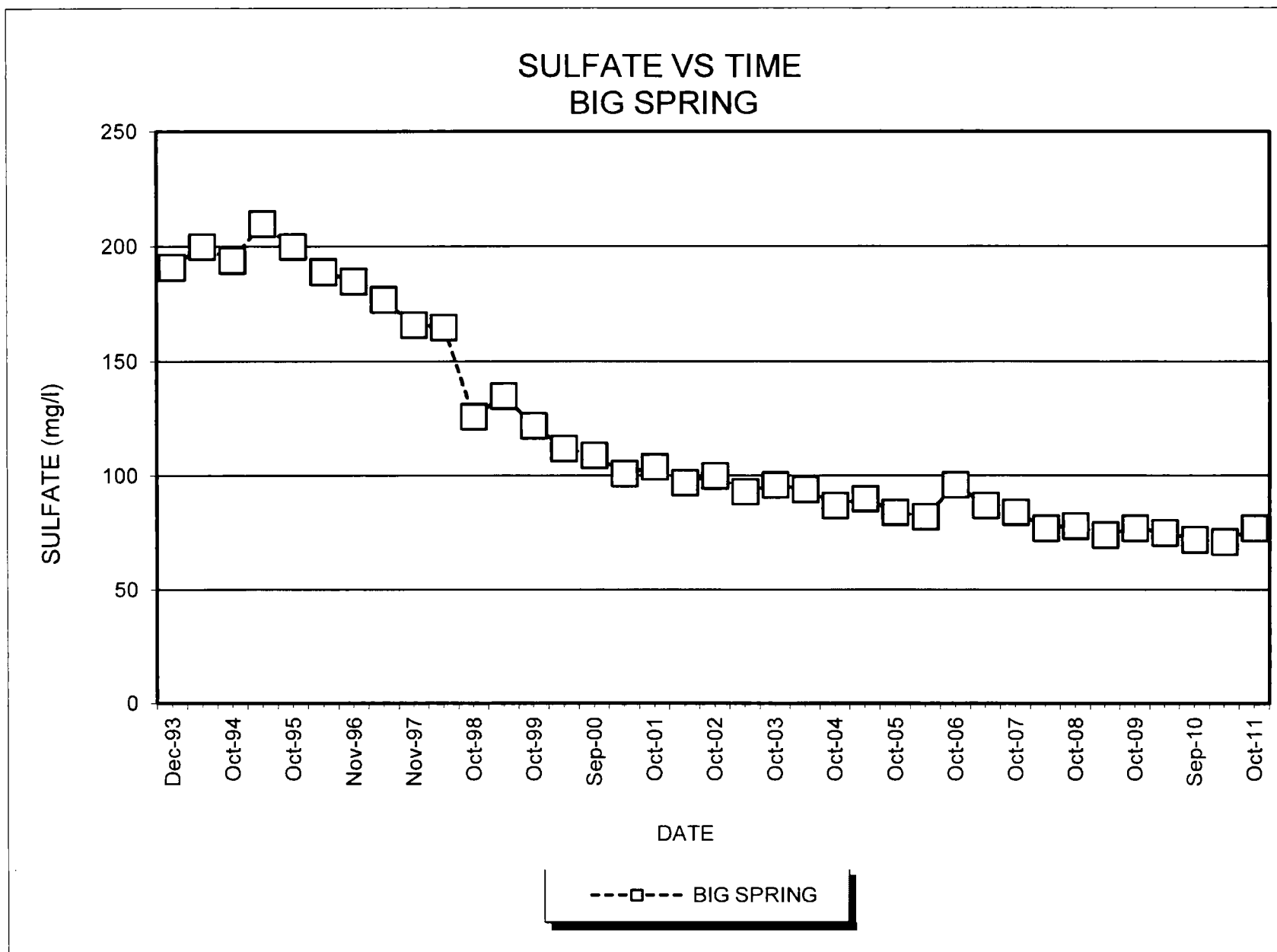
**SULFATE VS TIME
WELLS NEAR FORMER SCRUBBER POND**

**SULFATE VS TIME
WELLS NEAR WEST SIDE OF FACILITY
OR NEAR FORMER S-X POND**

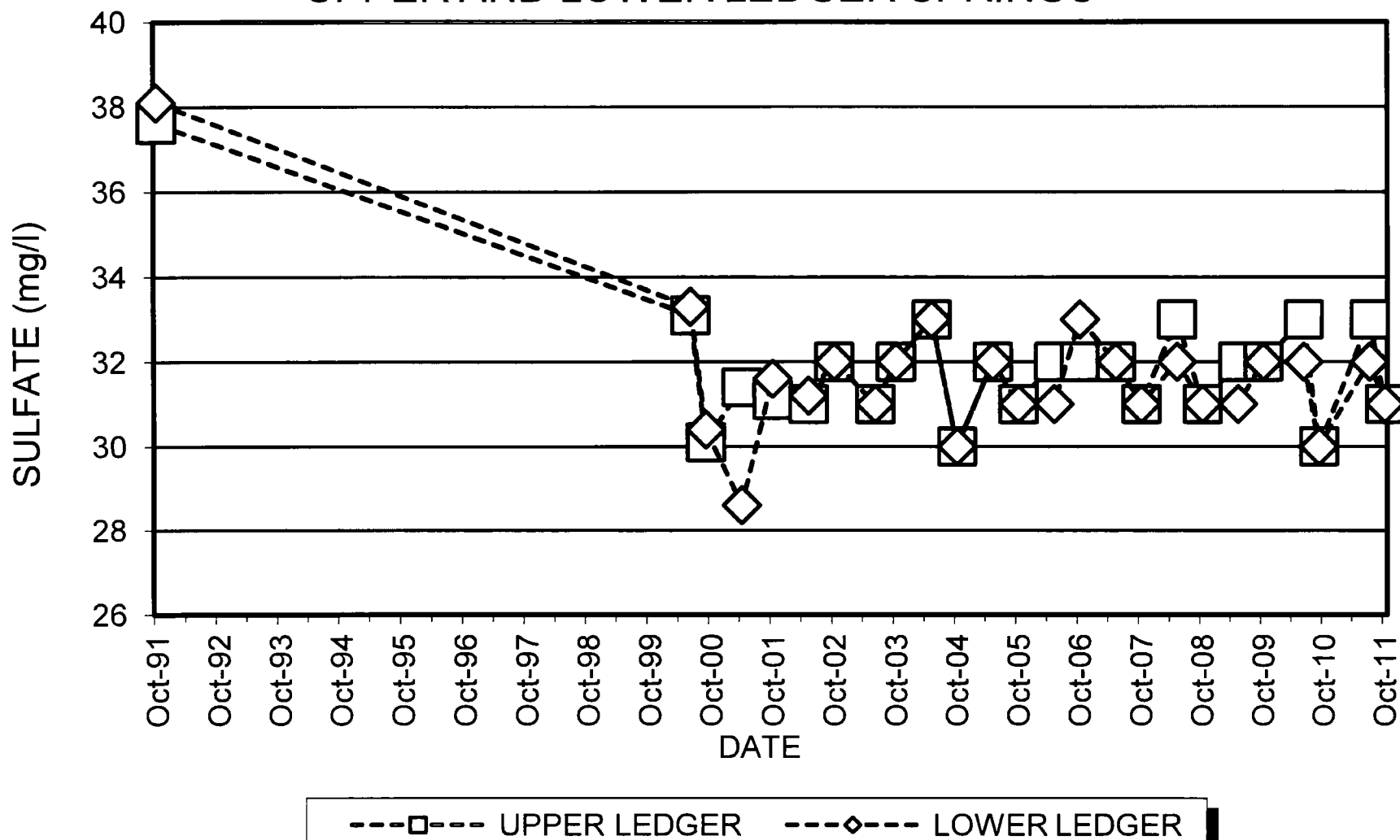
SULFATE VS TIME
WELL KM-8 NEAR FORMER S-X POND

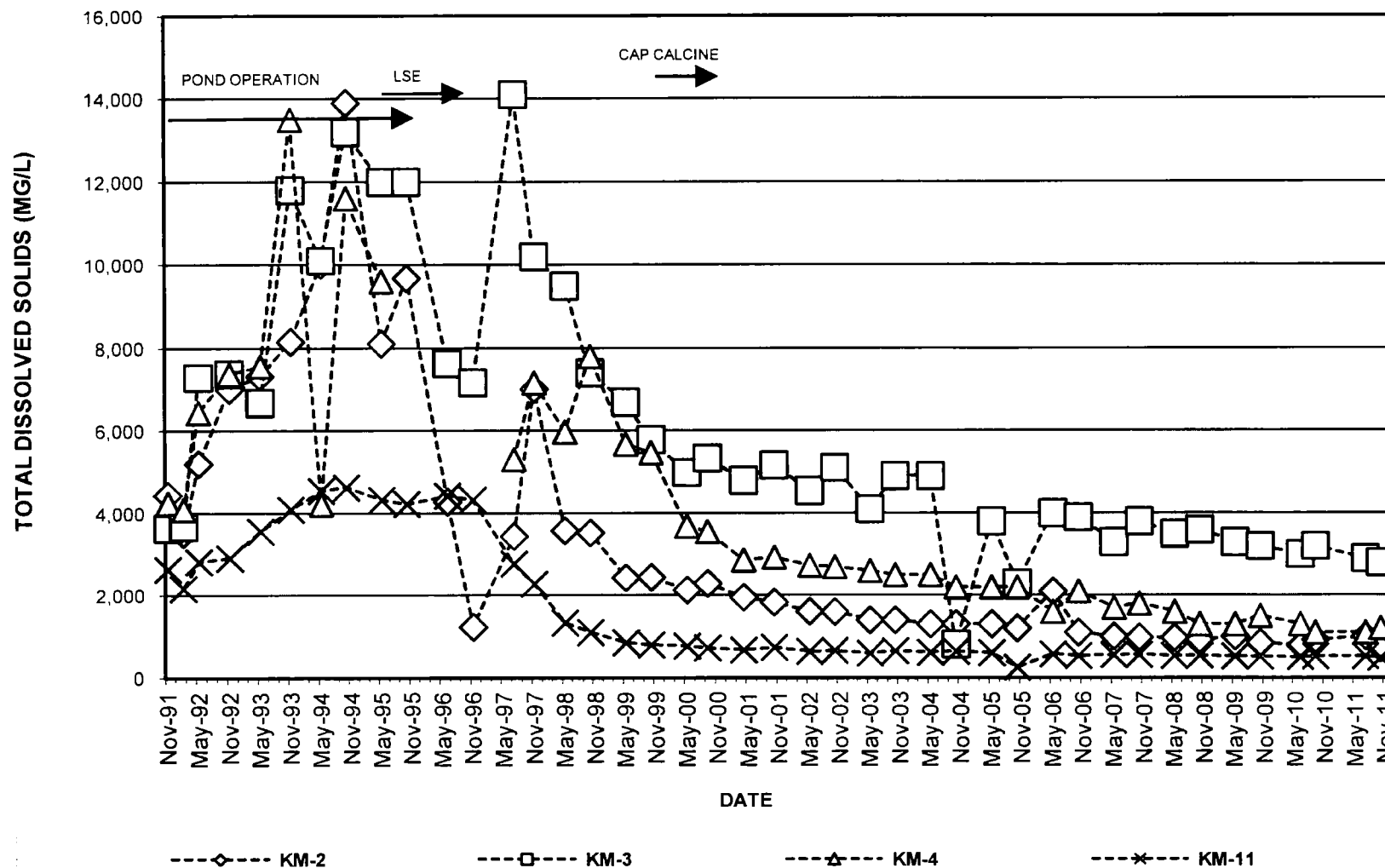


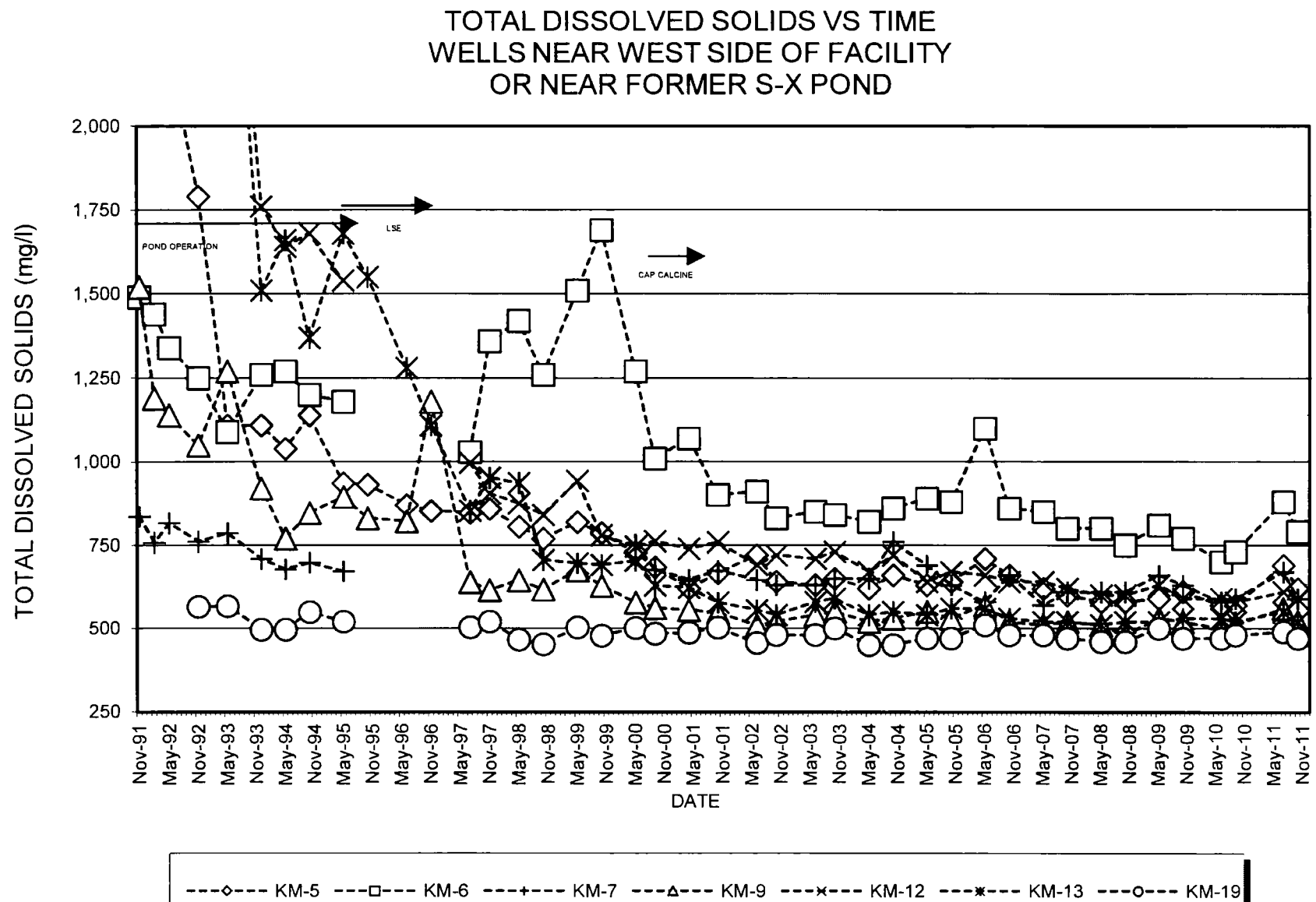


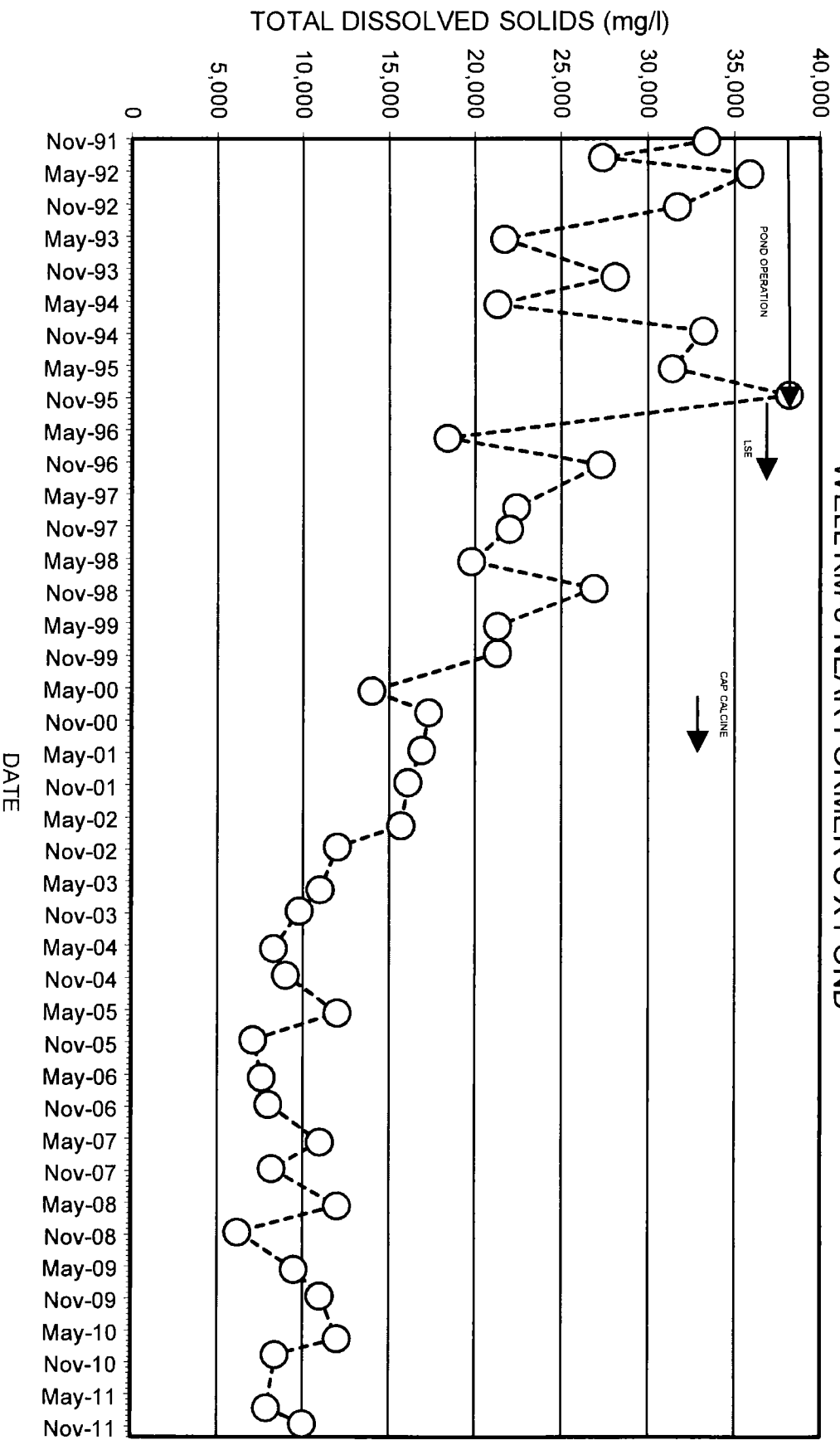


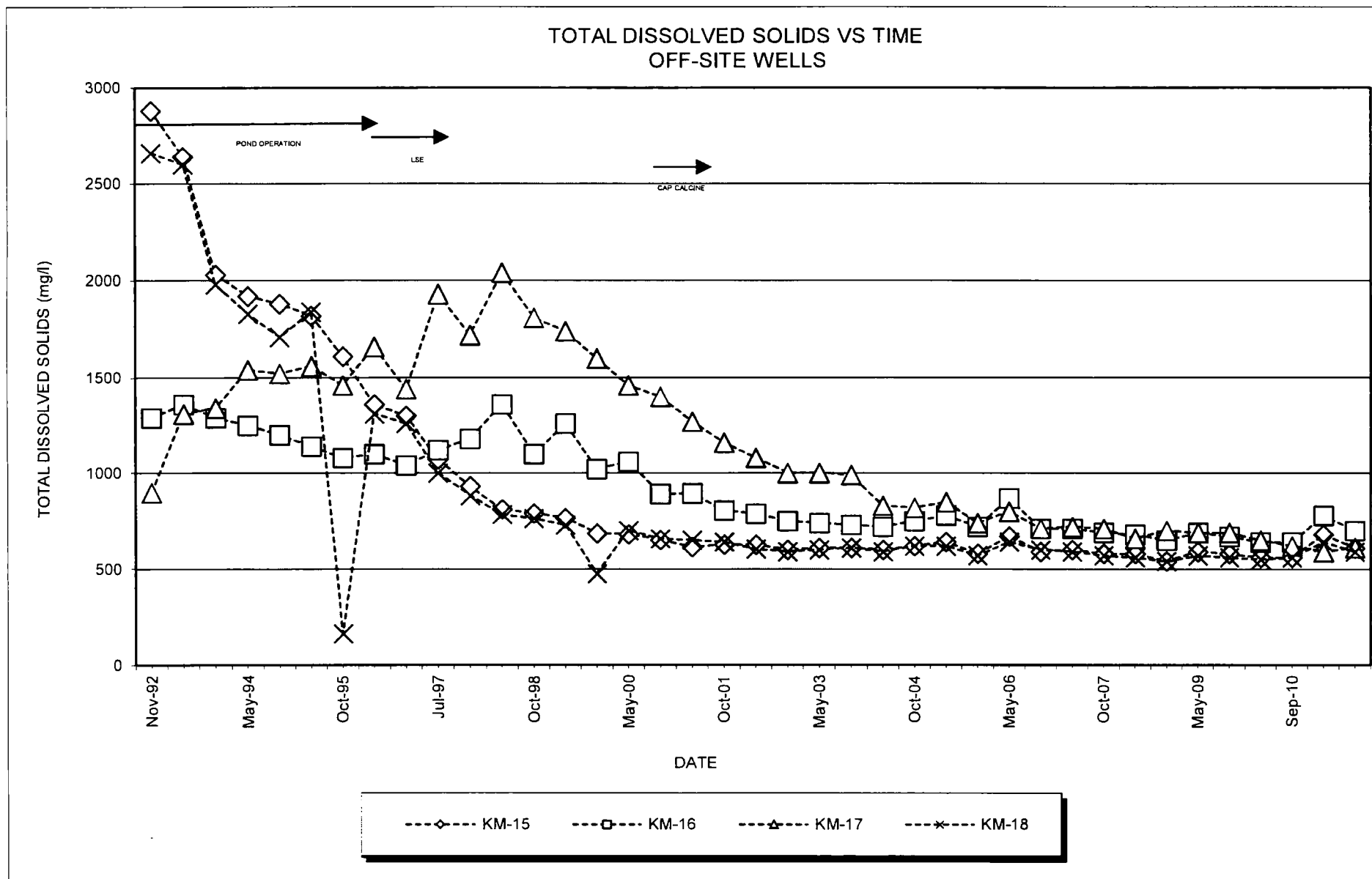
SULFATE VS TIME UPPER AND LOWER LEDGER SPRINGS

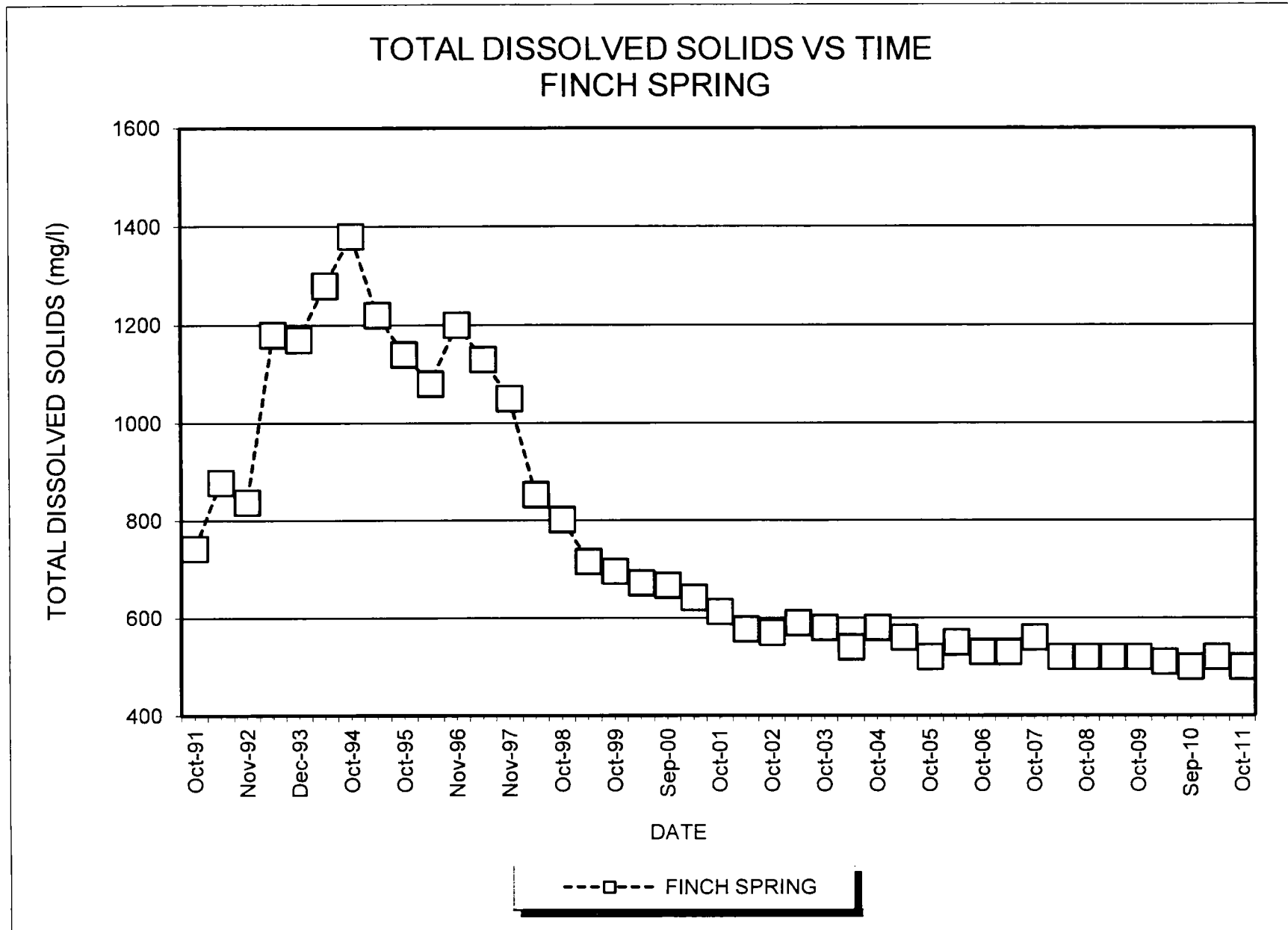


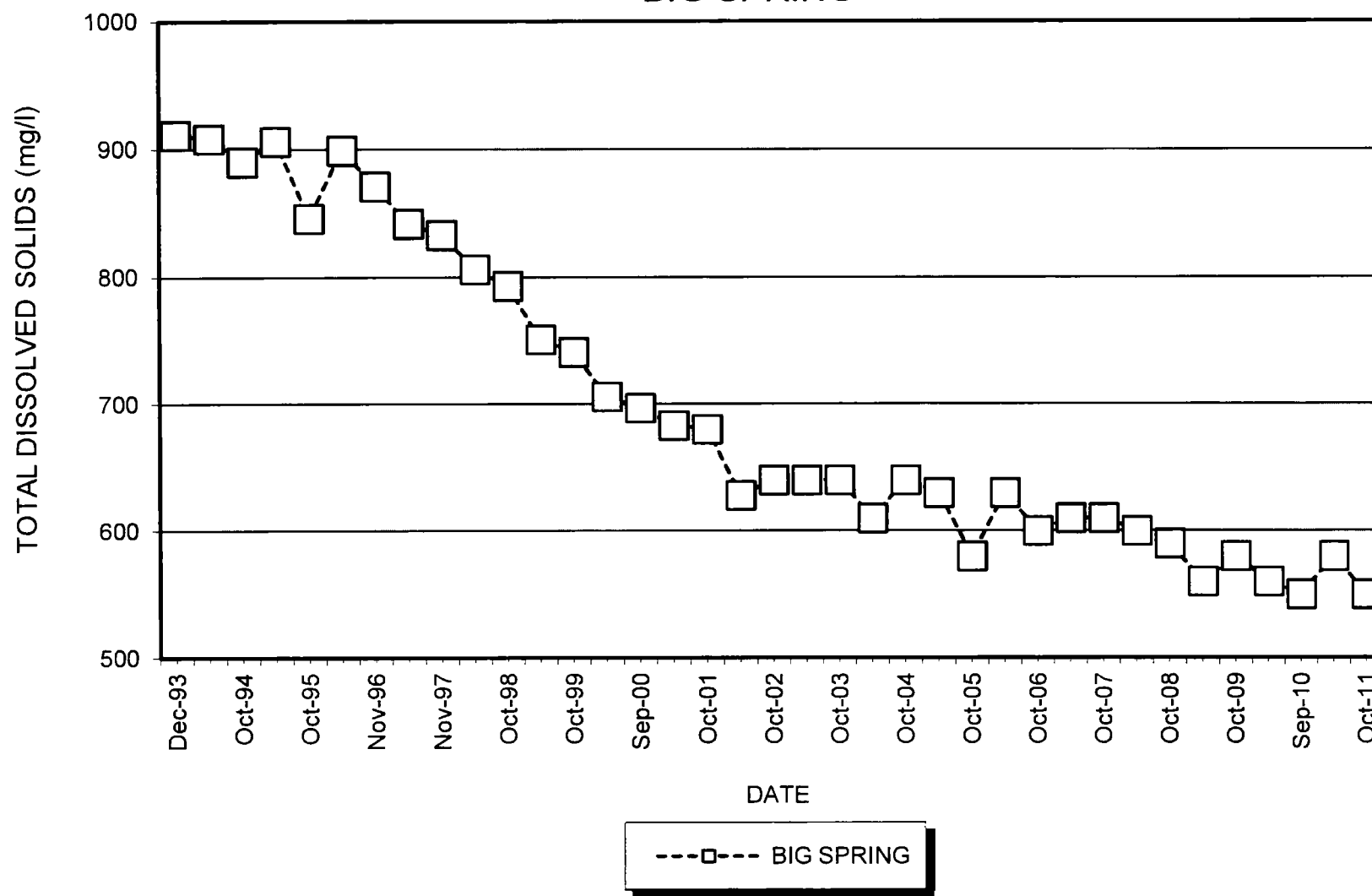
**TOTAL DISSOLVED SOLIDS VS TIME
WELLS NEAR FORMER SCRUBBER POND**

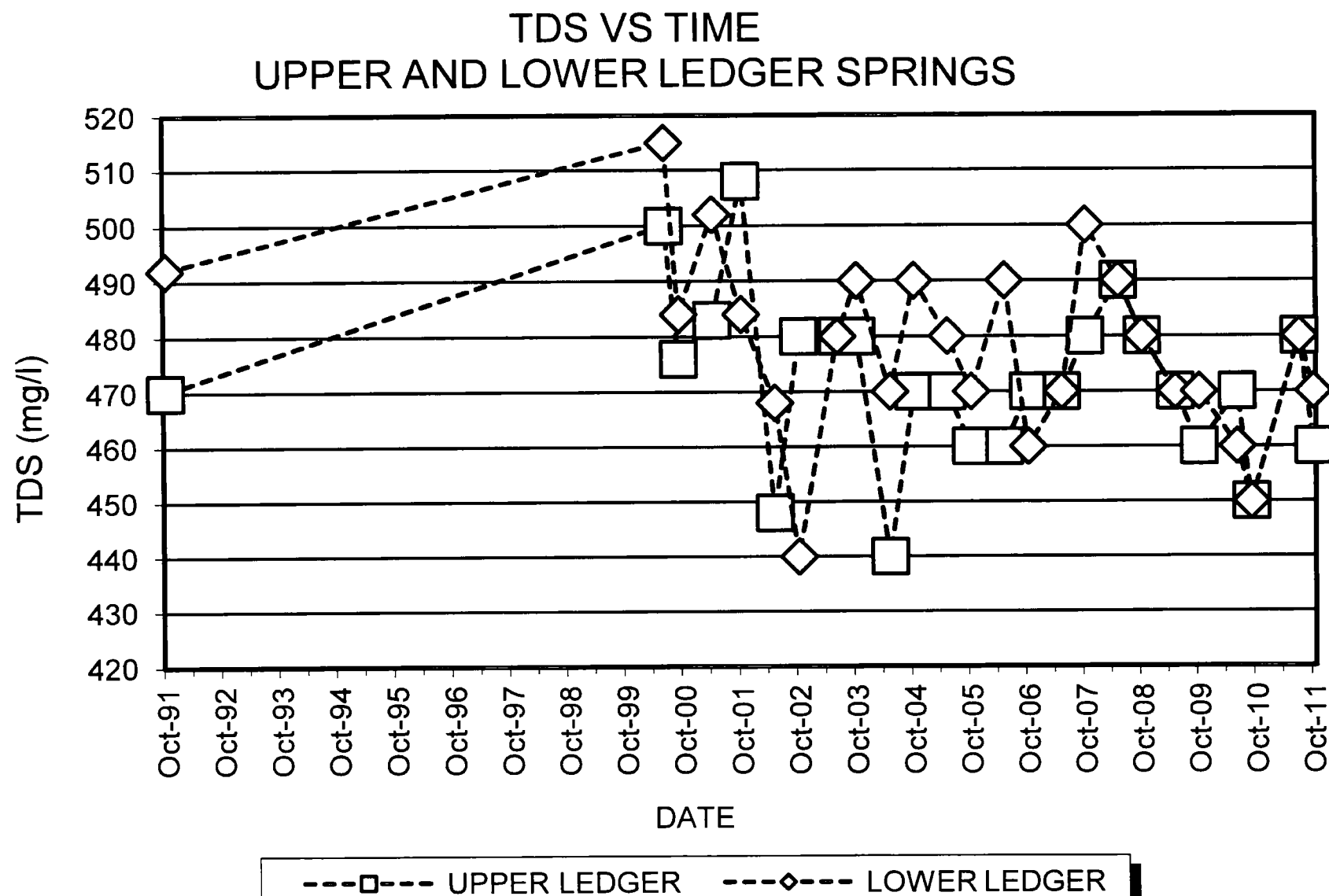


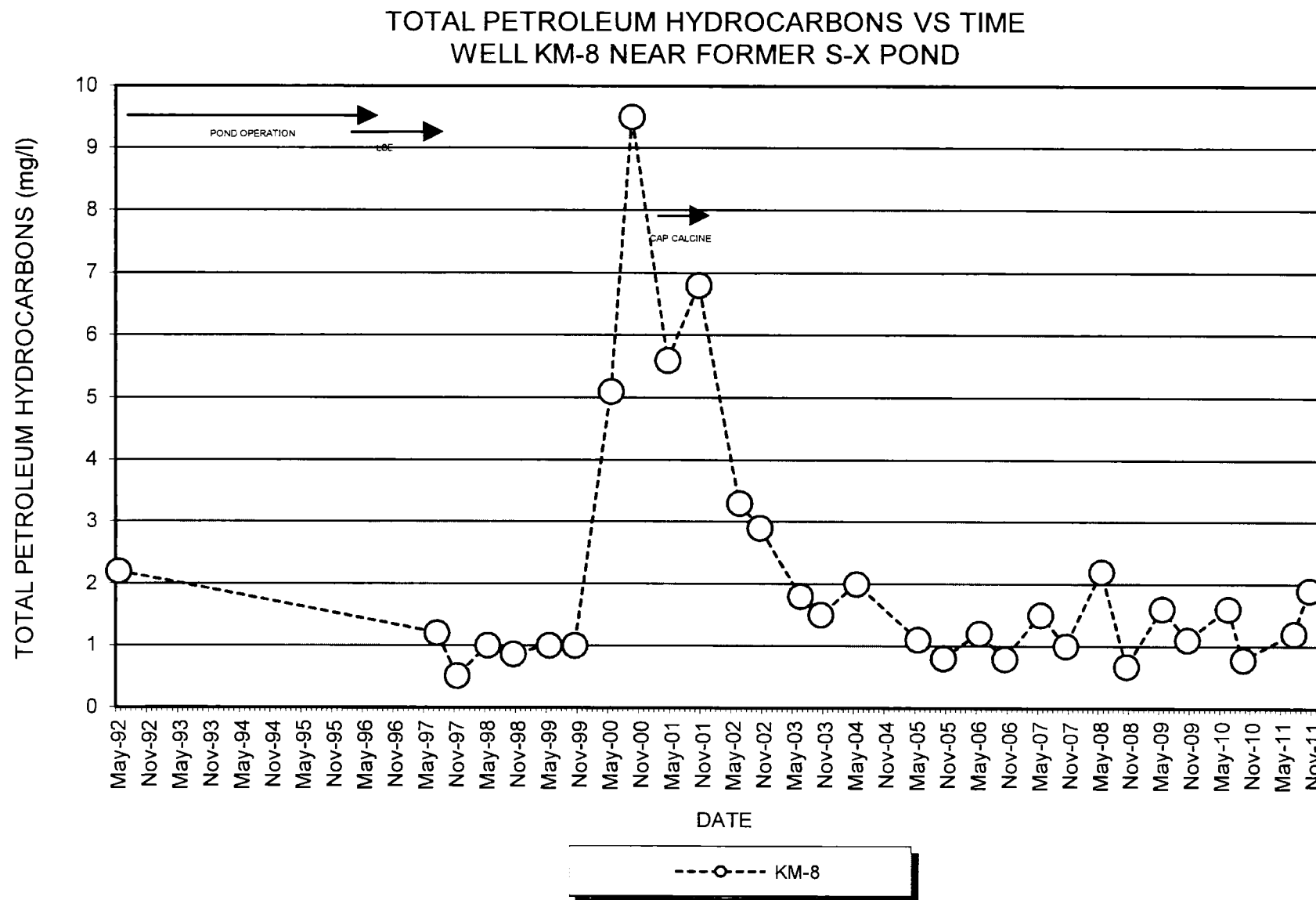
TOTAL DISSOLVED SOLIDS VS TIME
WELL KM-8 NEAR FORMER S-X POND





TOTAL DISSOLVED SOLIDS VS TIME
BIG SPRING

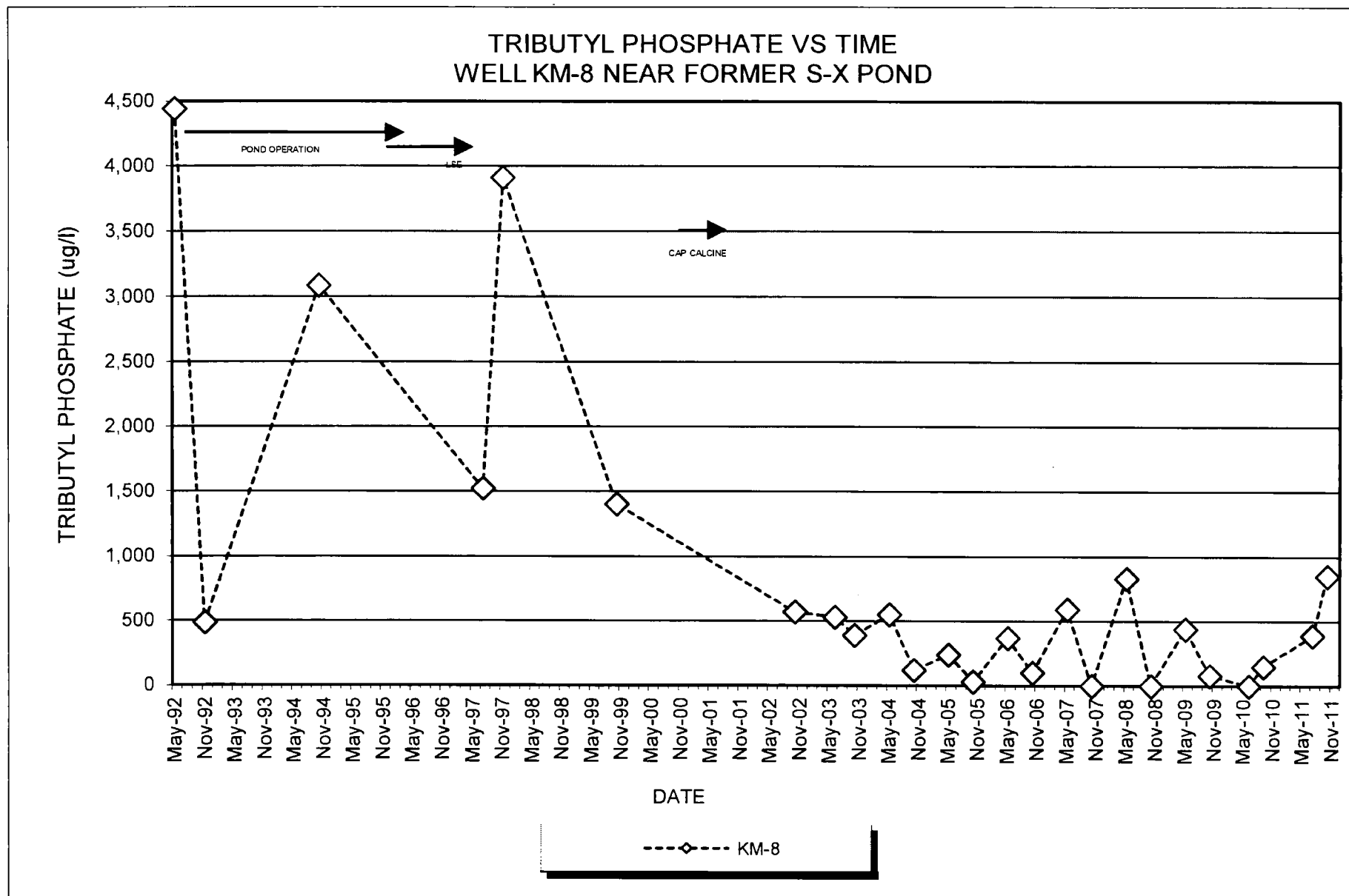




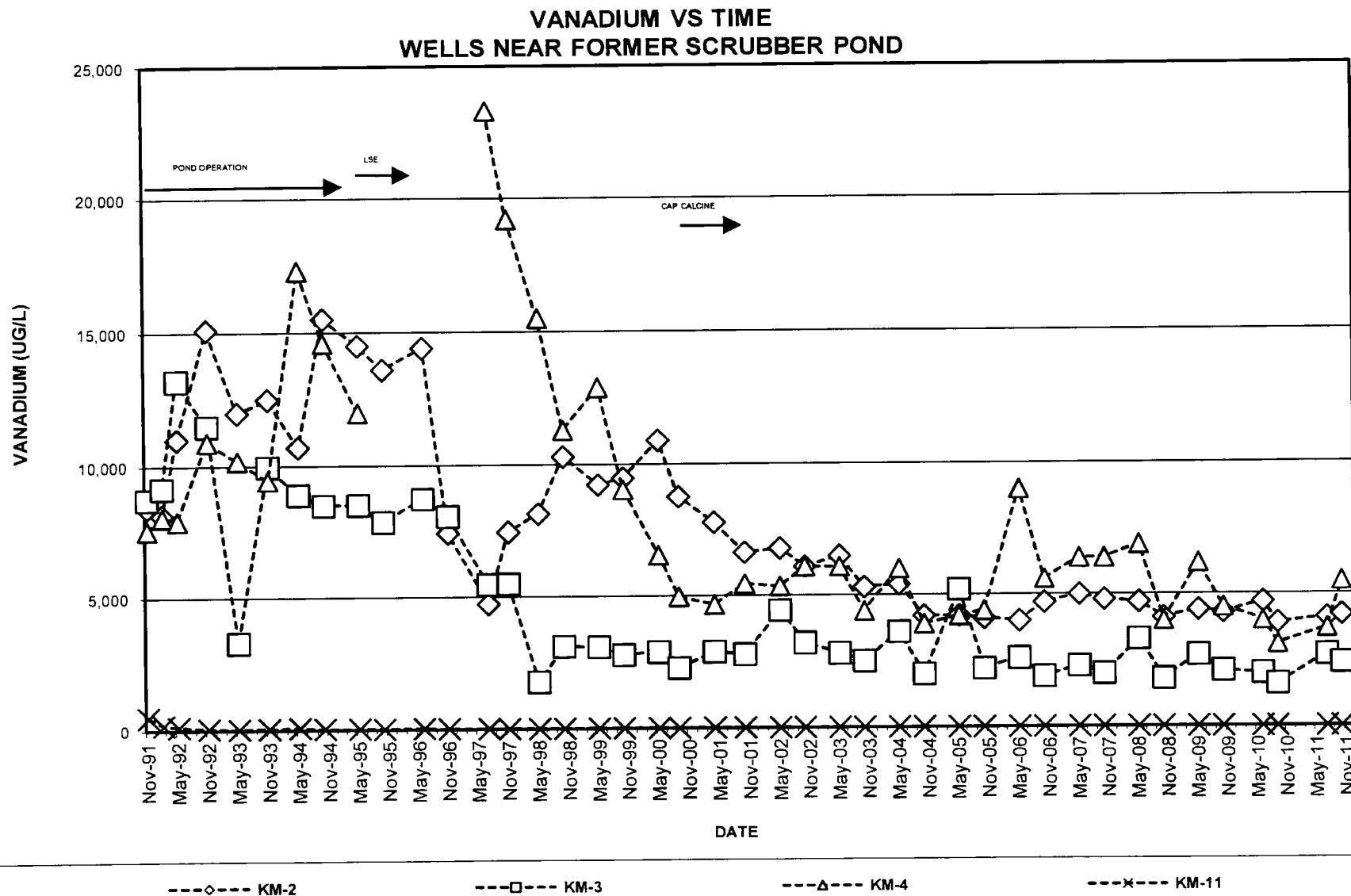
RBC FOR TPH IS 0.73 mg/l

KM-8 IS A POC WELL

1999 VALUES LESS THAN DETECTION



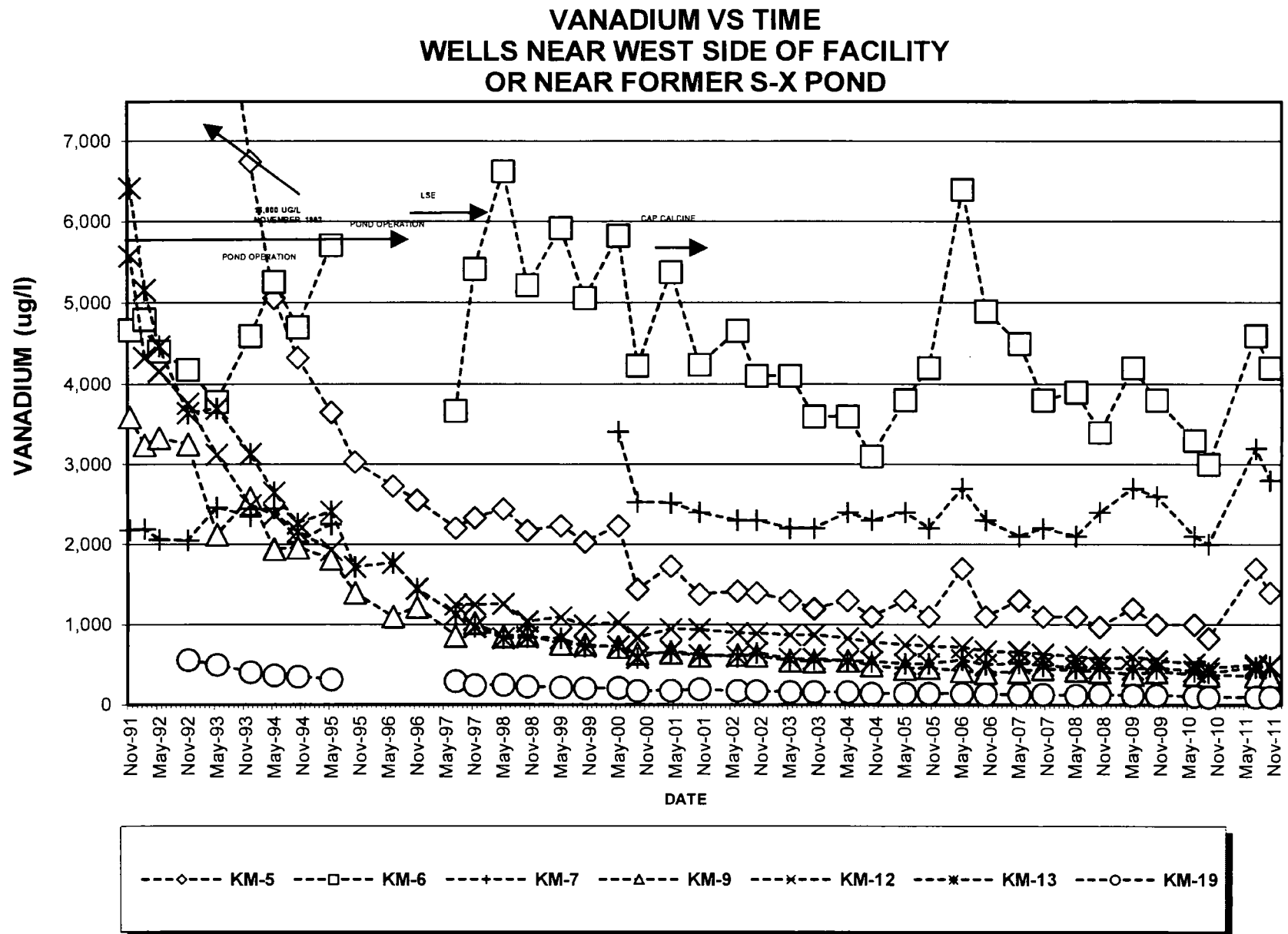
RBC FOR TRIBUTYL PHOSPHATE IS 180 ug/l
KM-8 IS A POC WELL
VALUES ESTIMATED AS DETECTED



RBC FOR VANADIUM IS 260 ug/l

KM-2, KM-3, KM-11 ARE POC WELLS

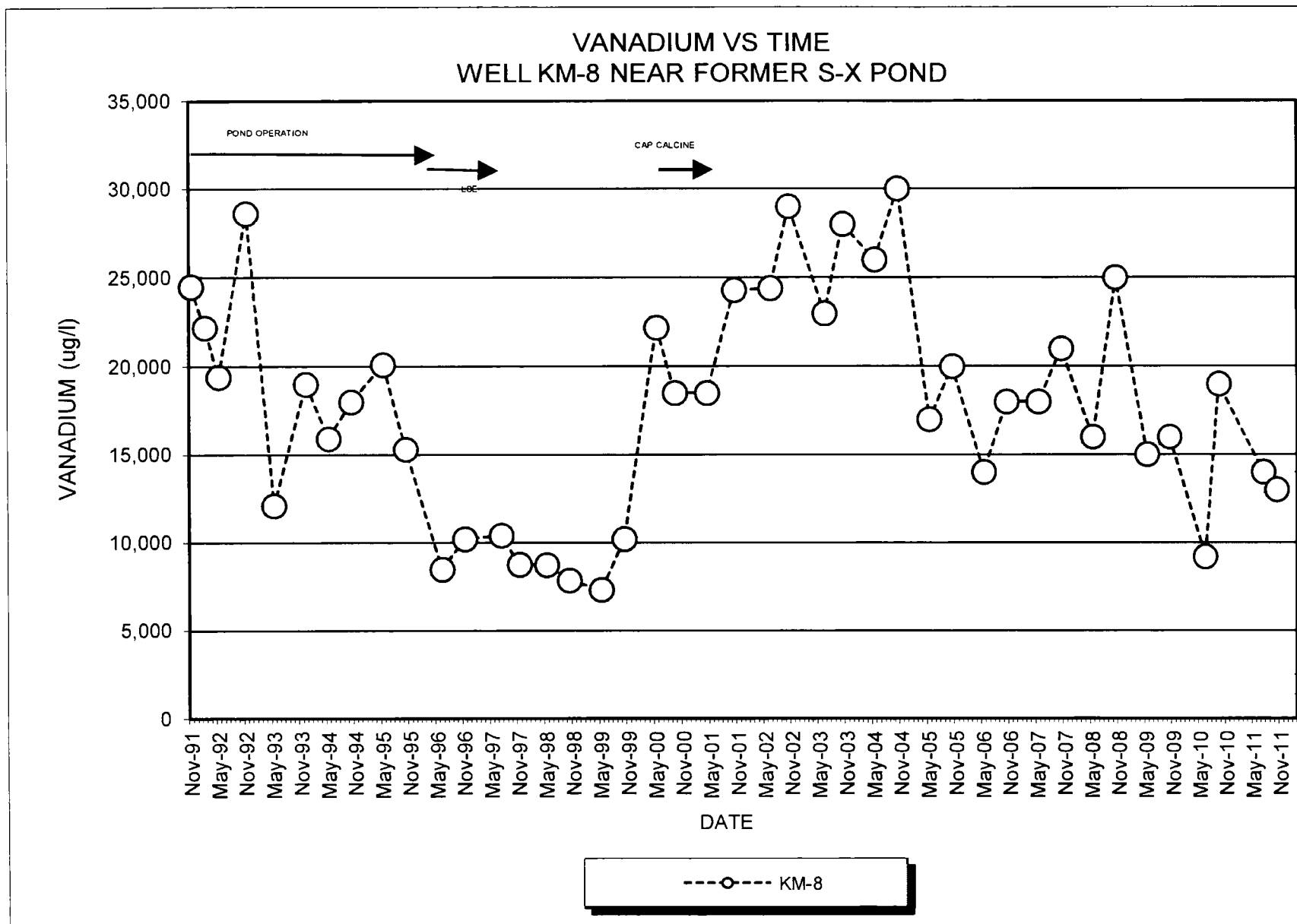
VALUES LESS THAN DETECTION ARE PLOTTED AT DETECTION LIMIT



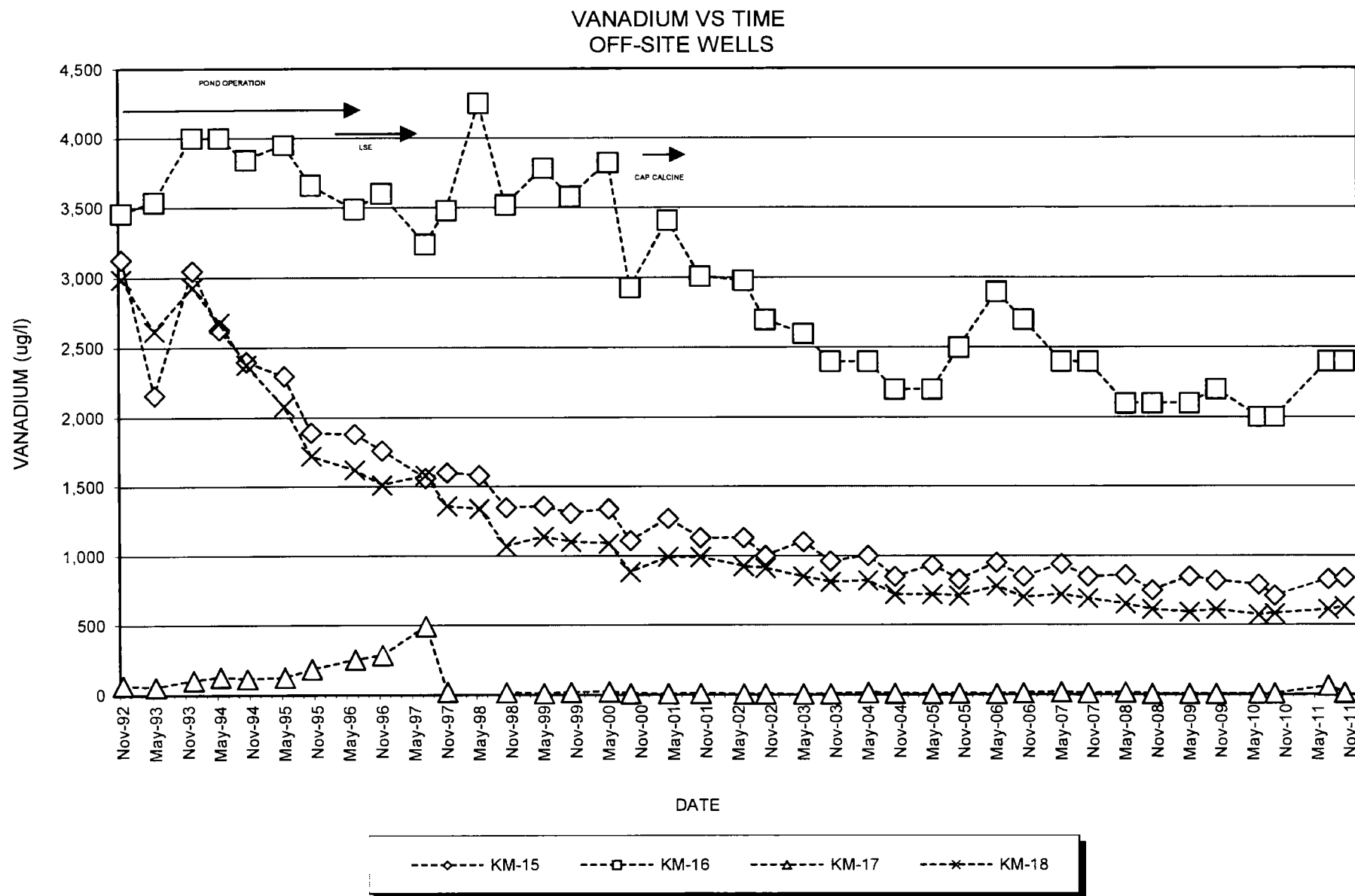
RBC FOR VANADIUM IS 260 ug/l

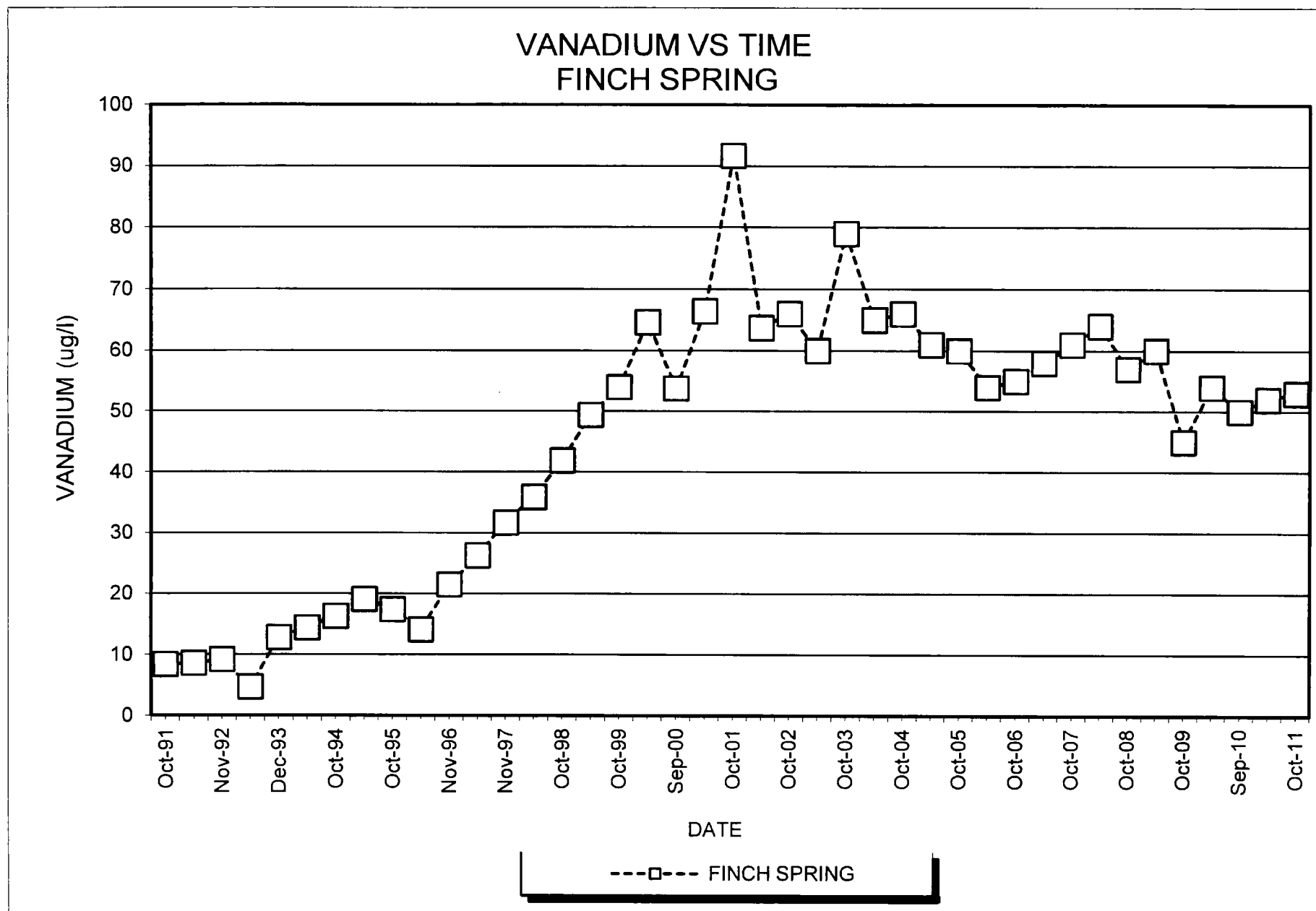
KM-2, KM-3, KM-11 ARE POC WELLS

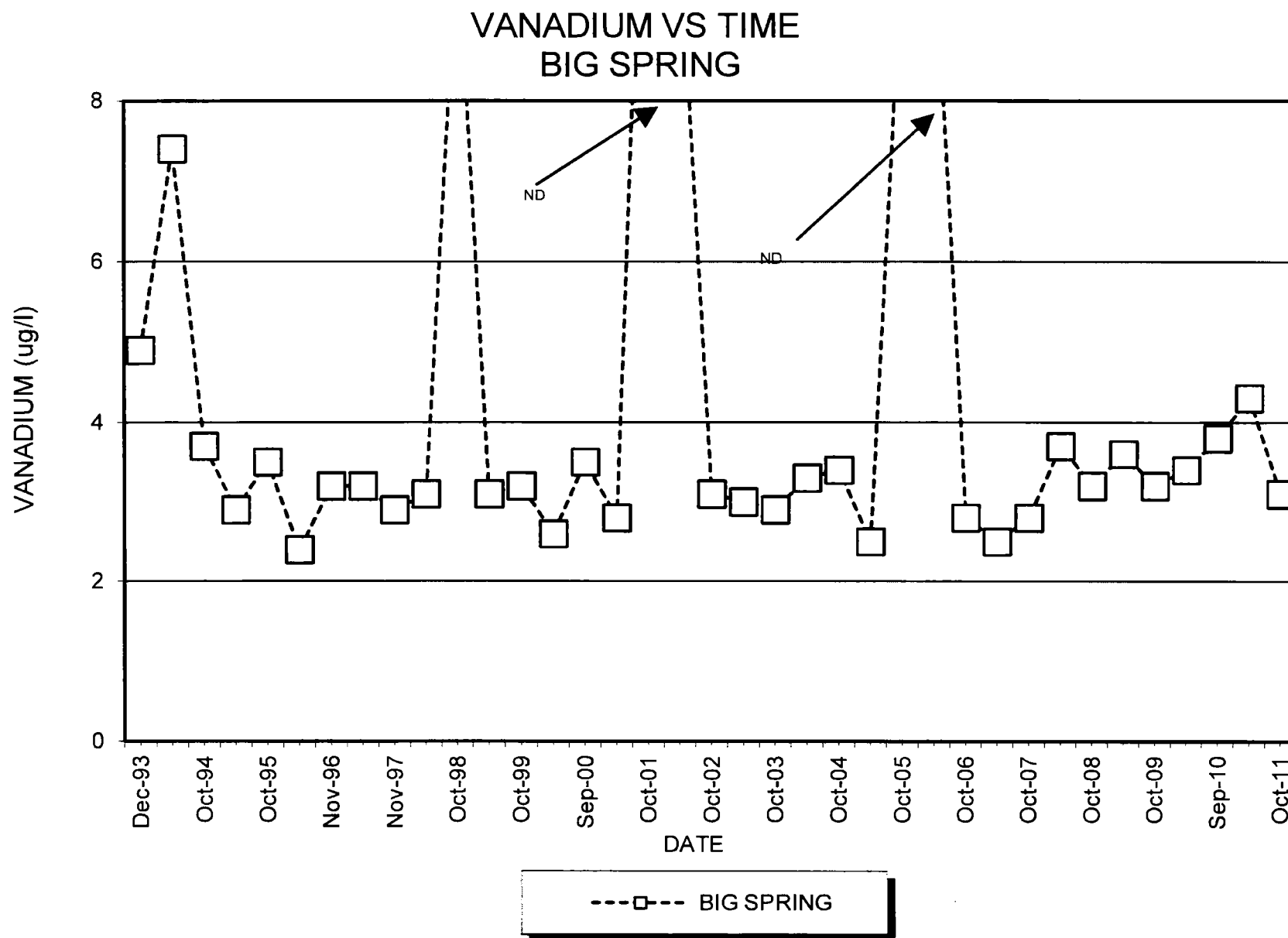
VALUES LESS THAN DETECTION ARE PLOTTED AT DETECTION LIMIT



RBC FOR VANADIUM IS 260 ug/l
KM-8 IS A POC WELLS



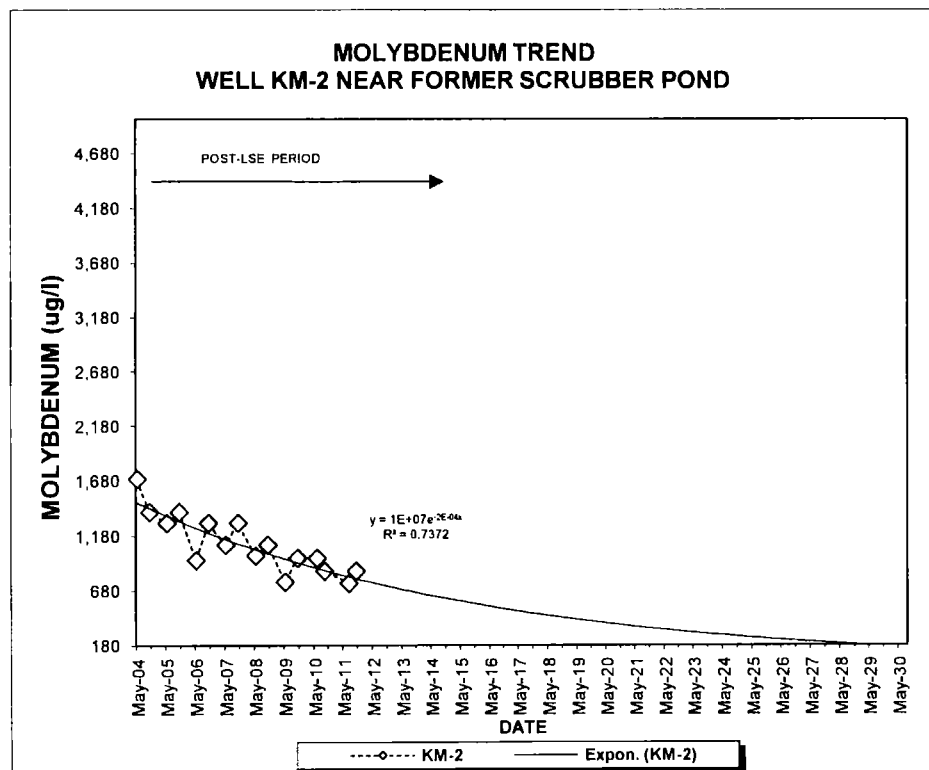
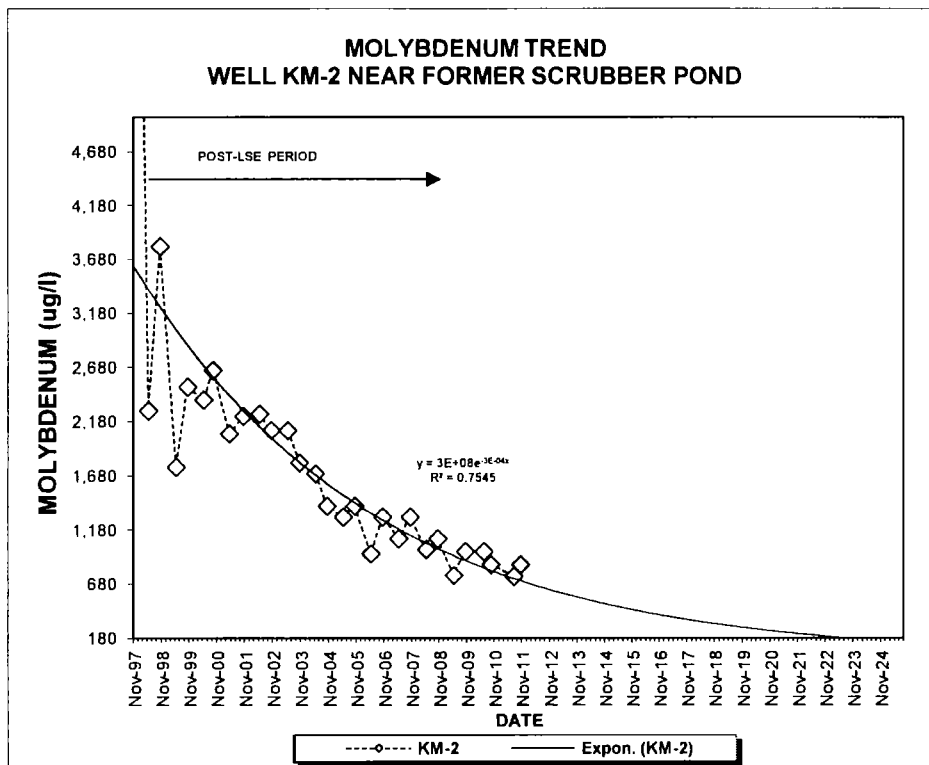




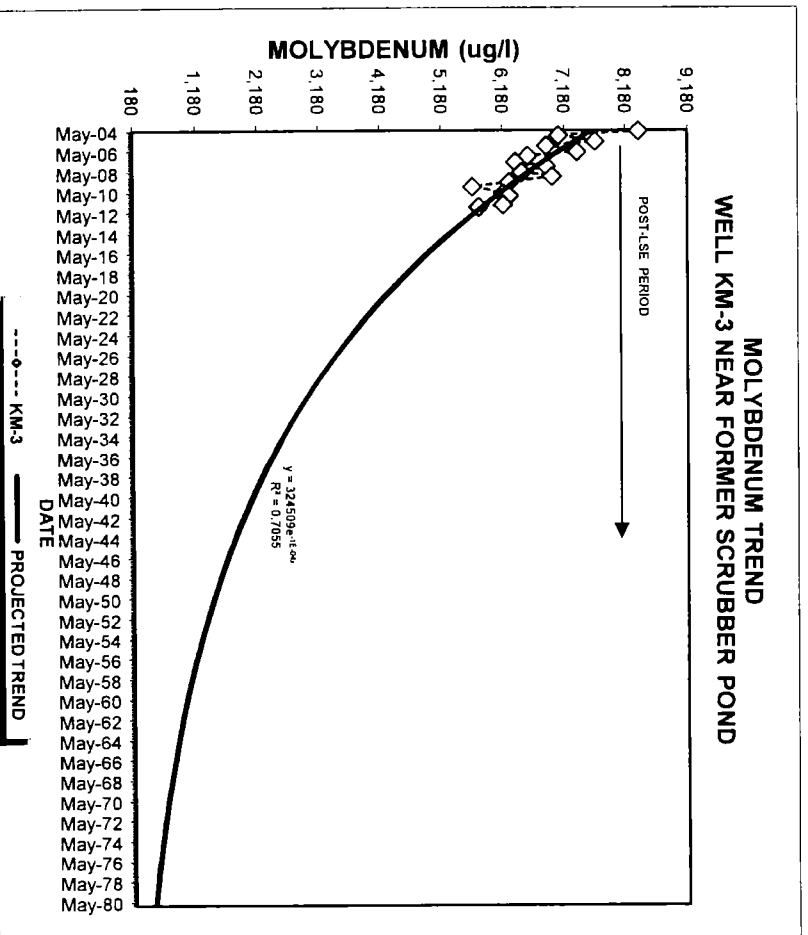
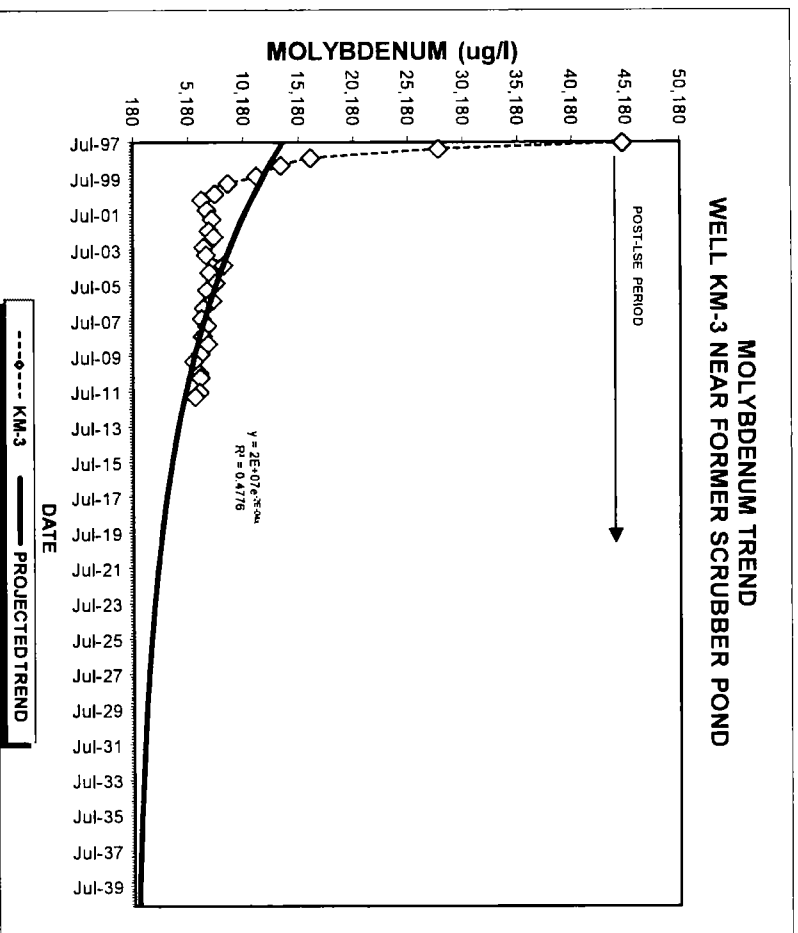
Values less than detection annotated on figure

APPENDIX B

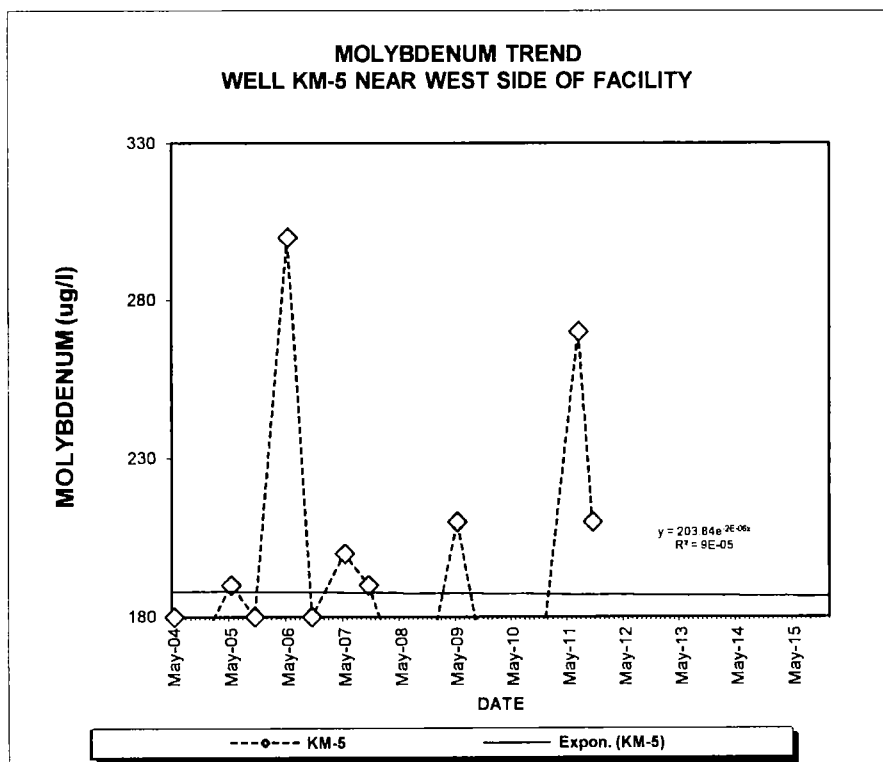
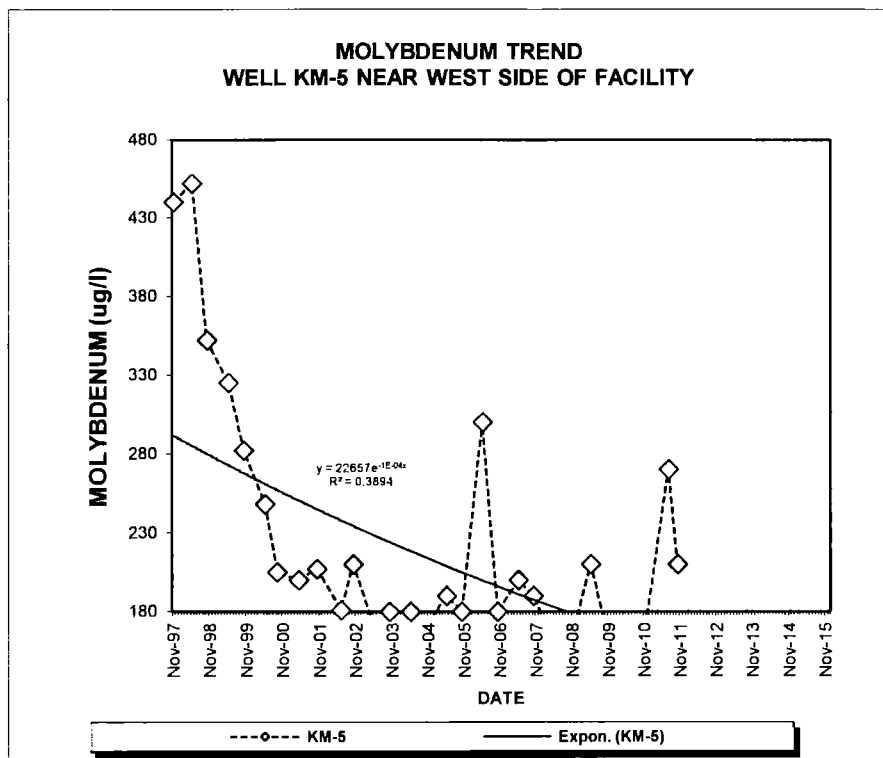
COC CONCENTRATION TRENDS WITH TIME AND PROJECTED TRENDS

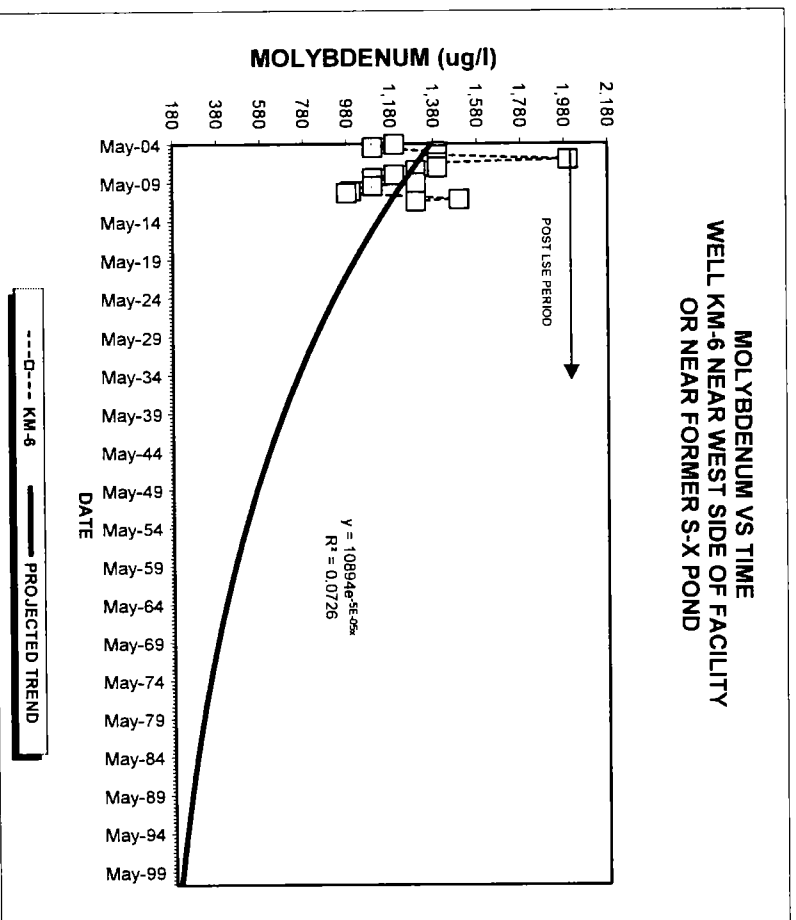
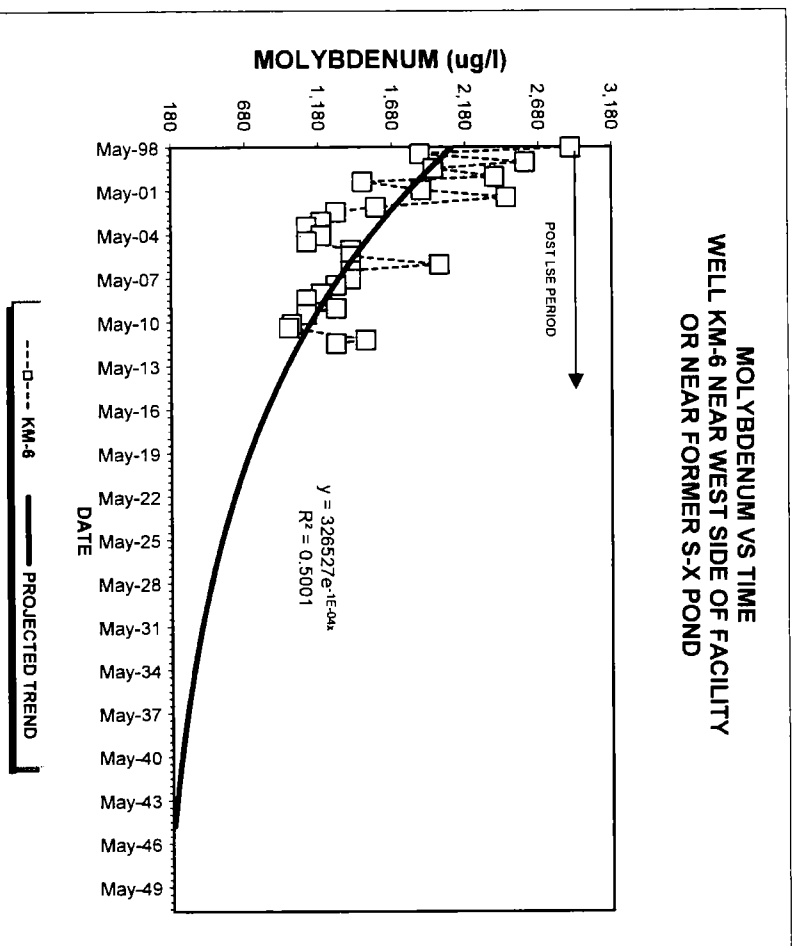


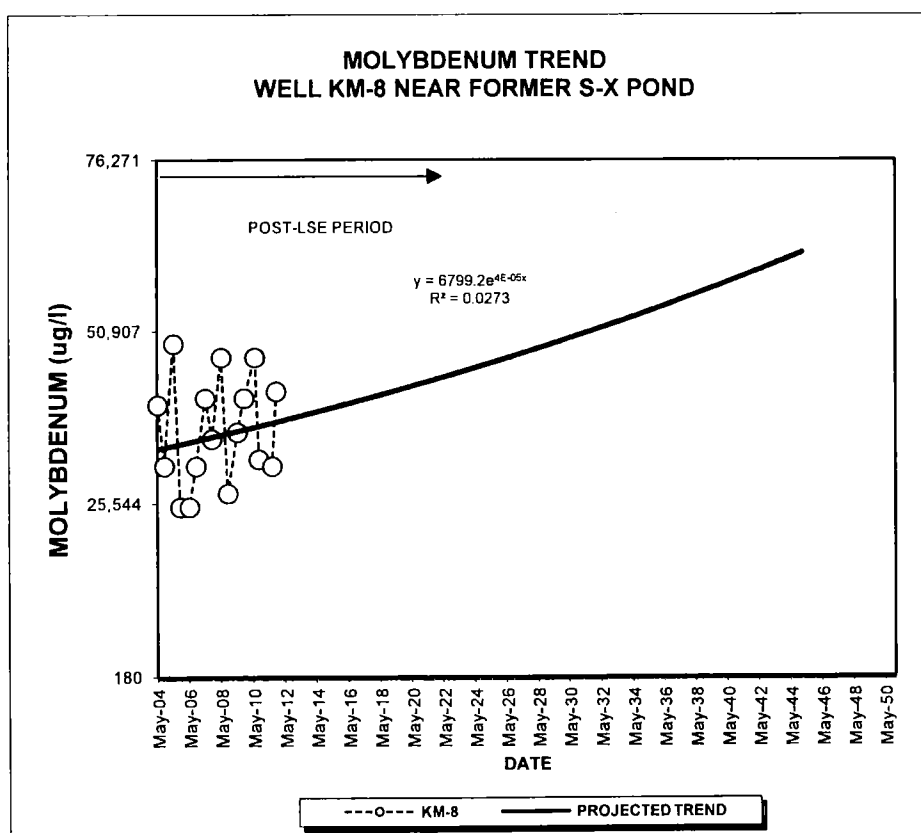
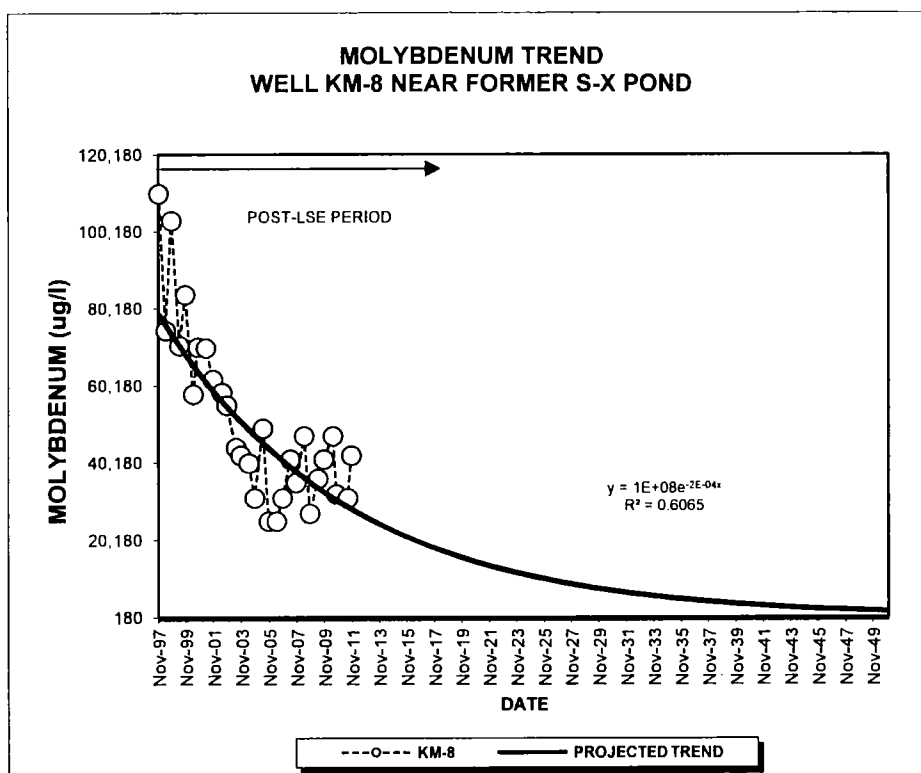
FIGURE

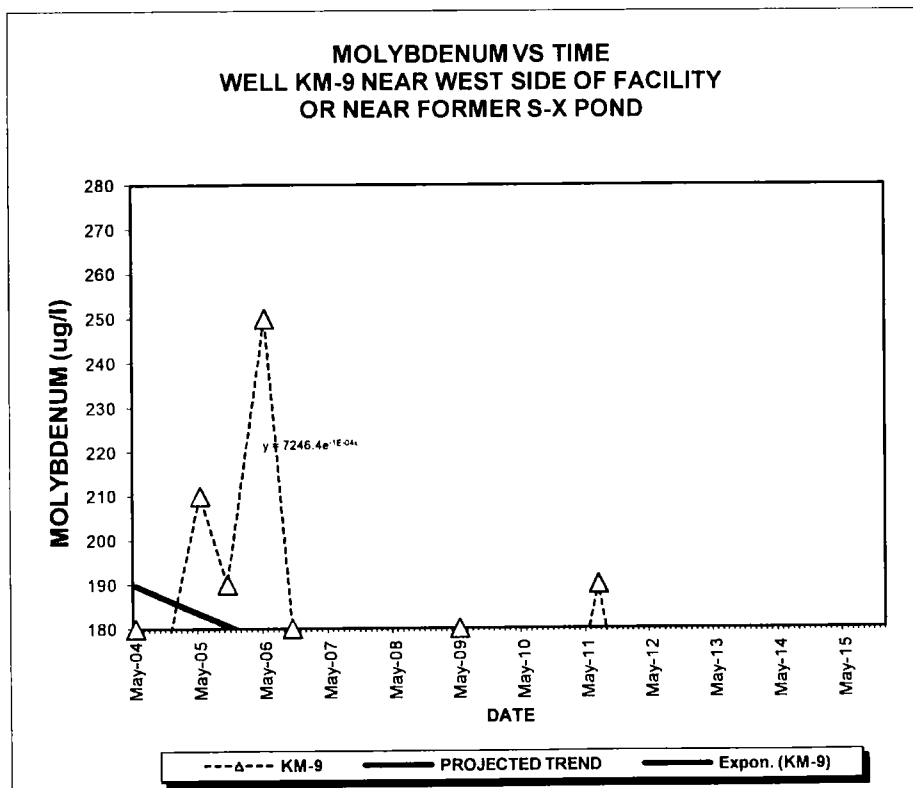
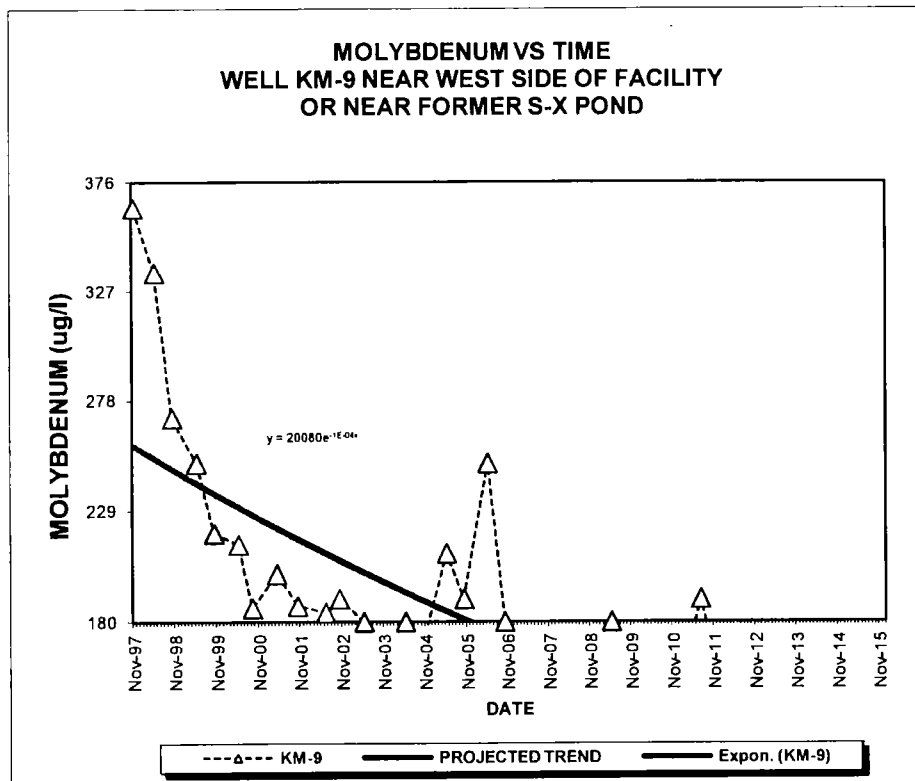


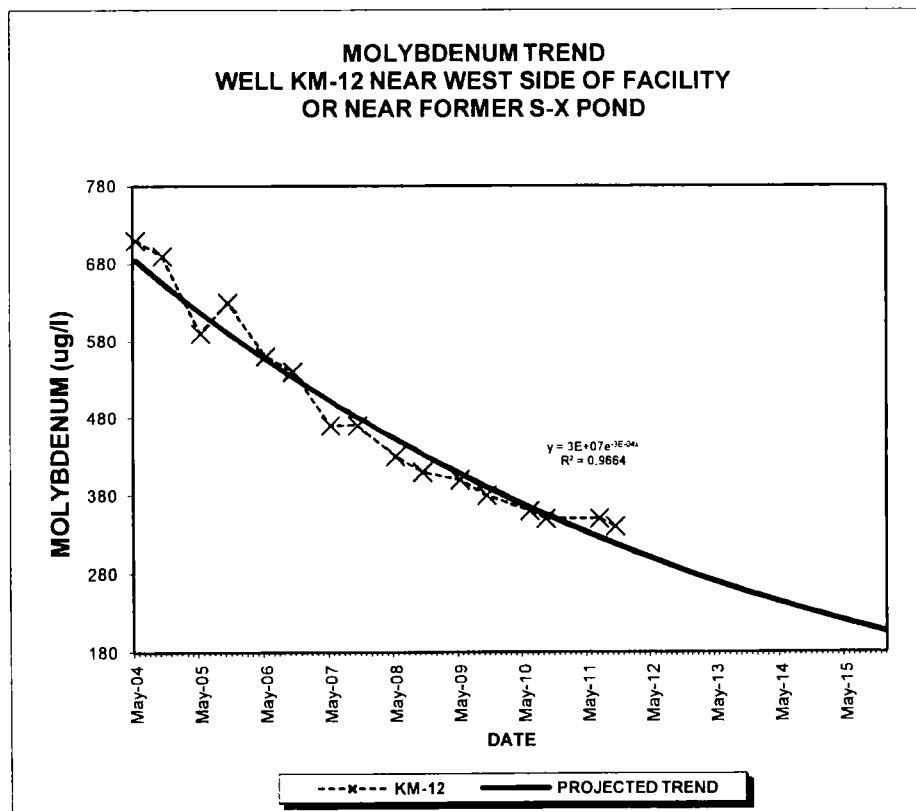
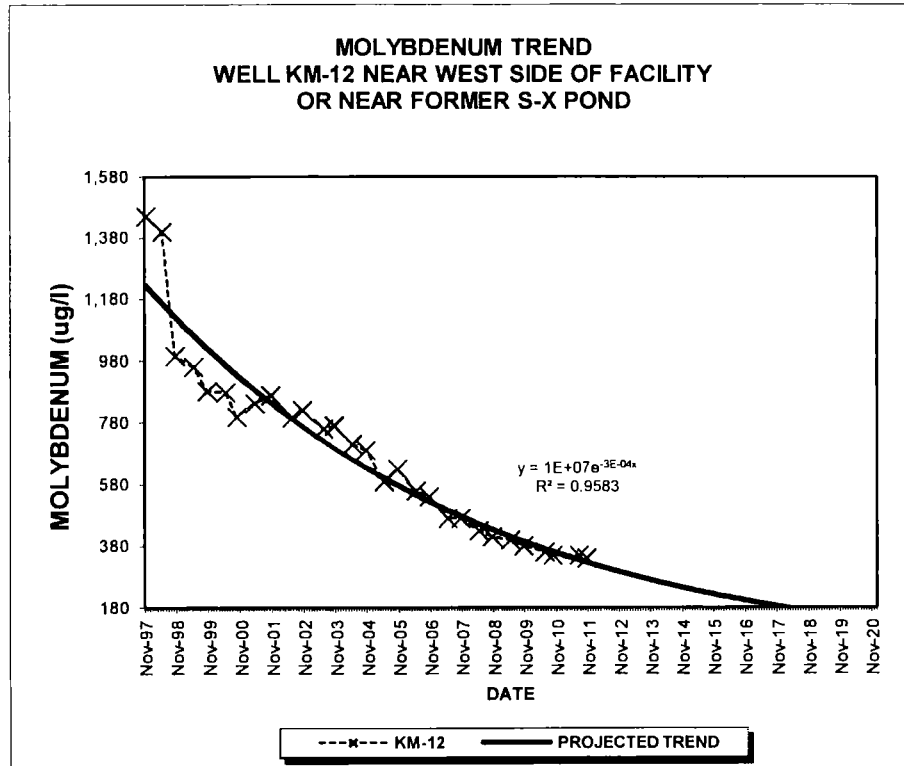
FIGURE

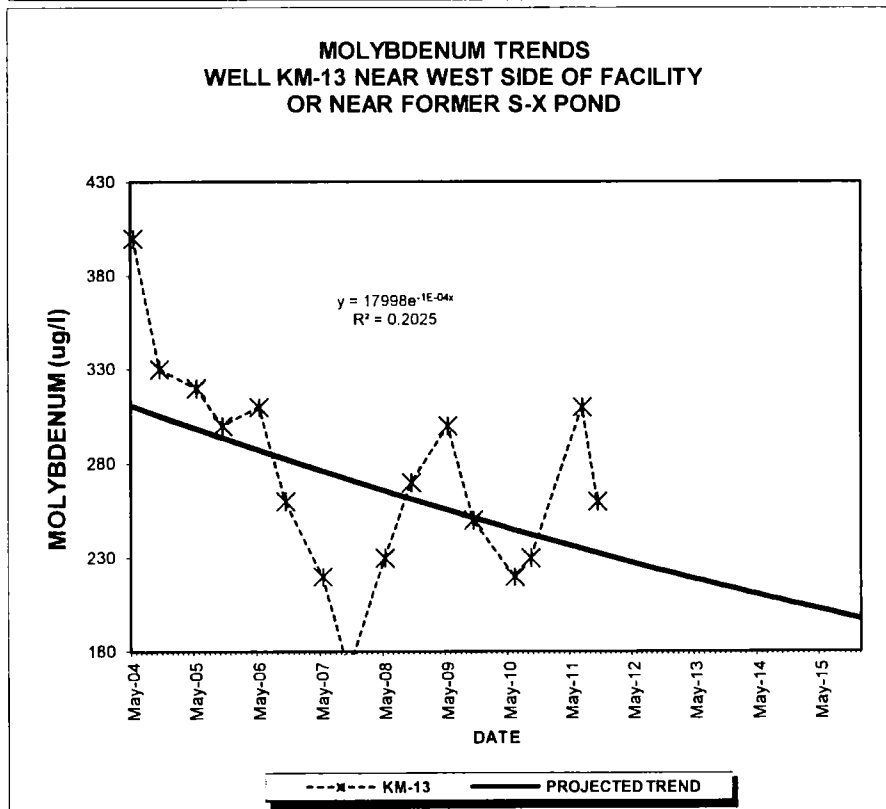
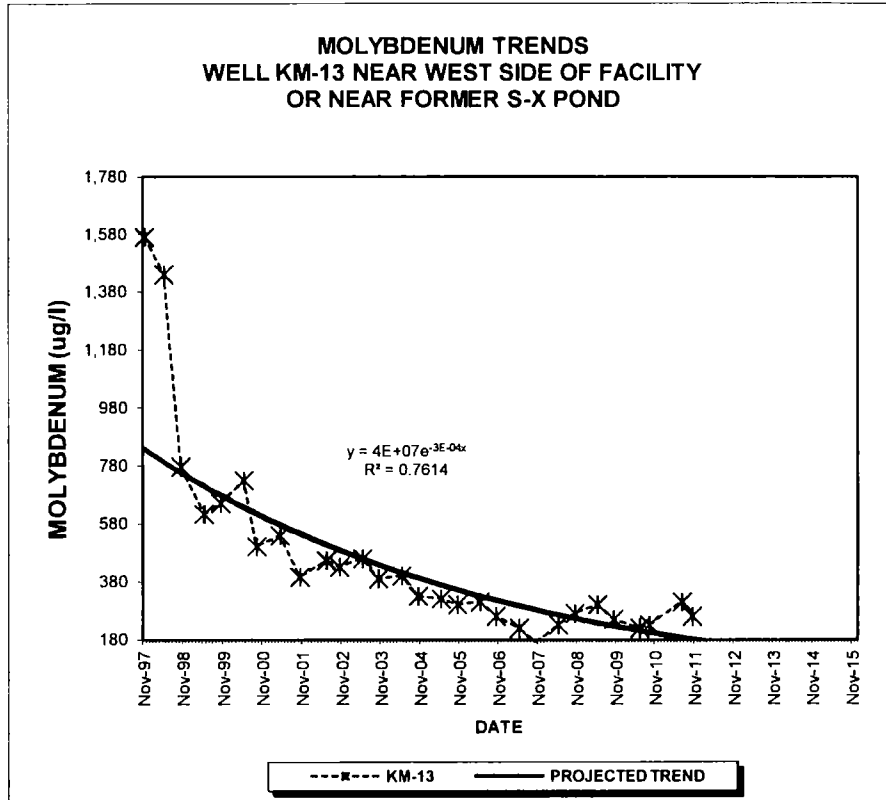


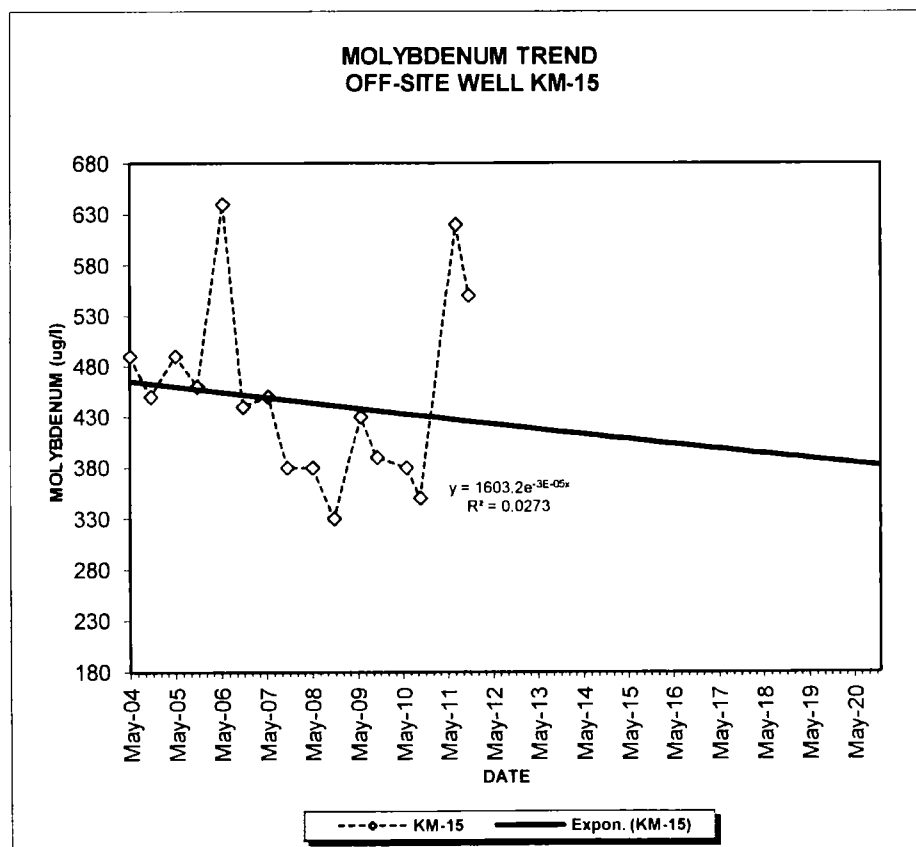
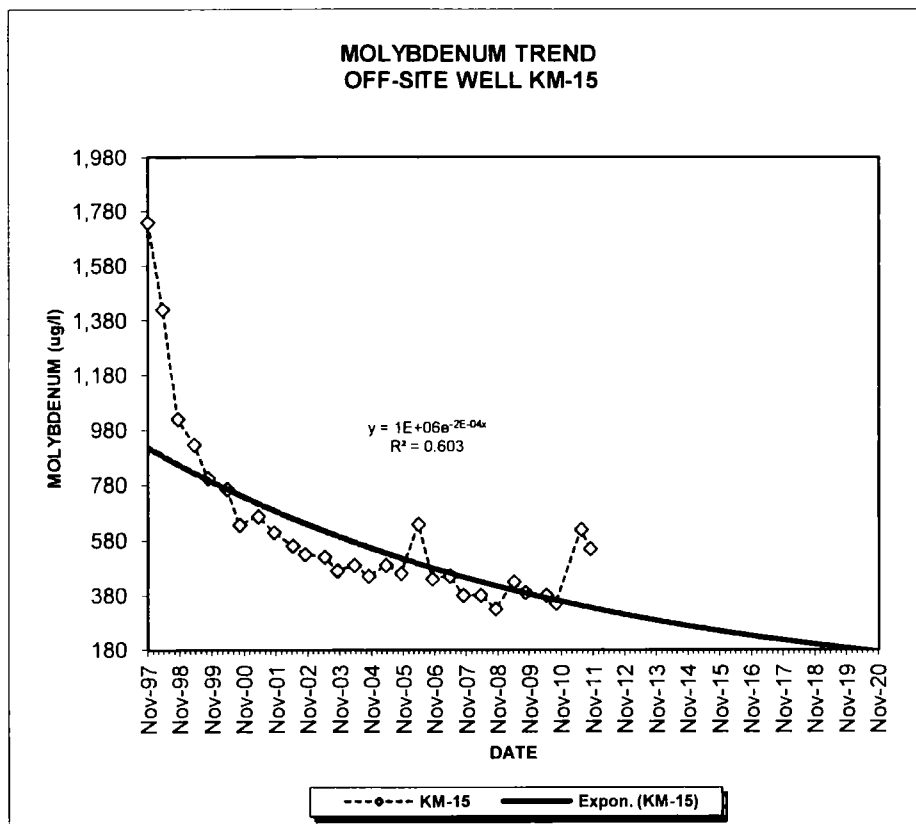


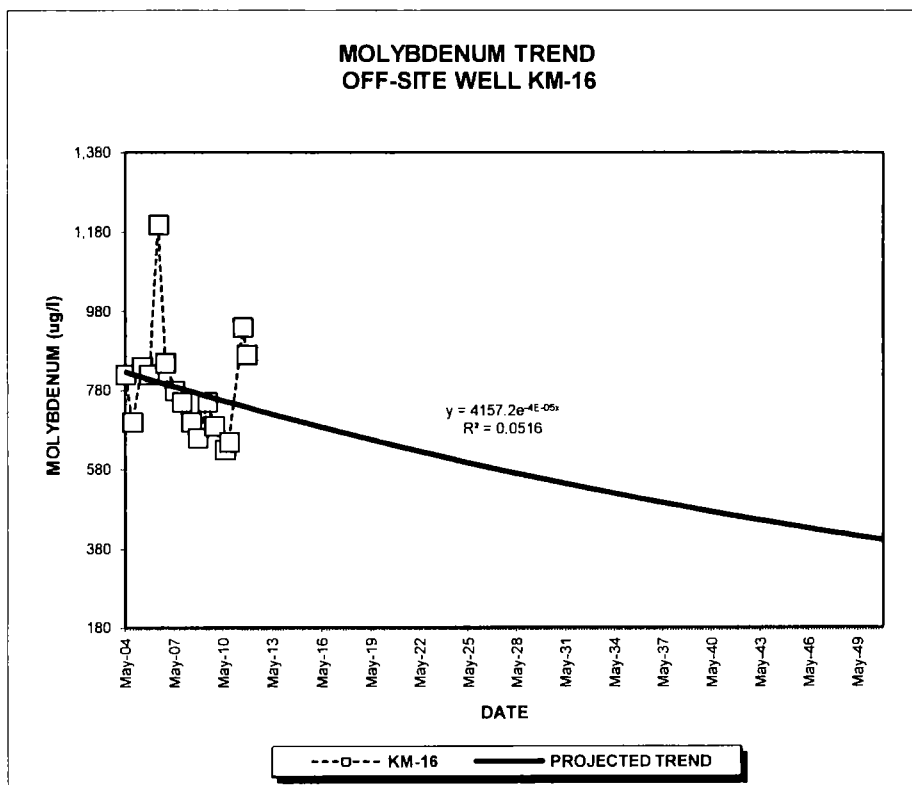
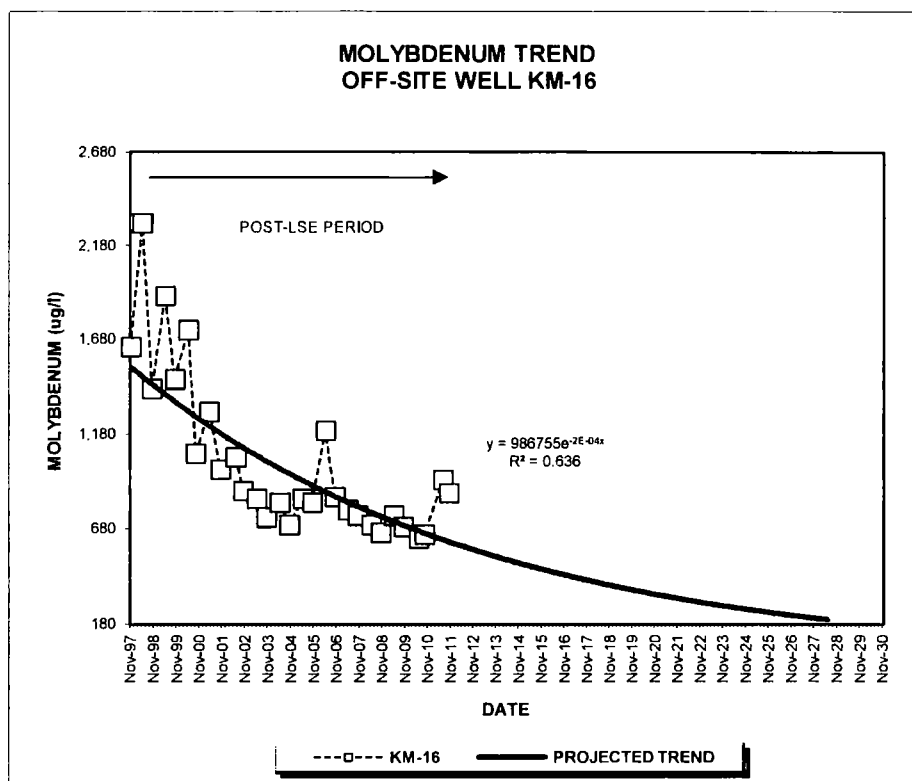


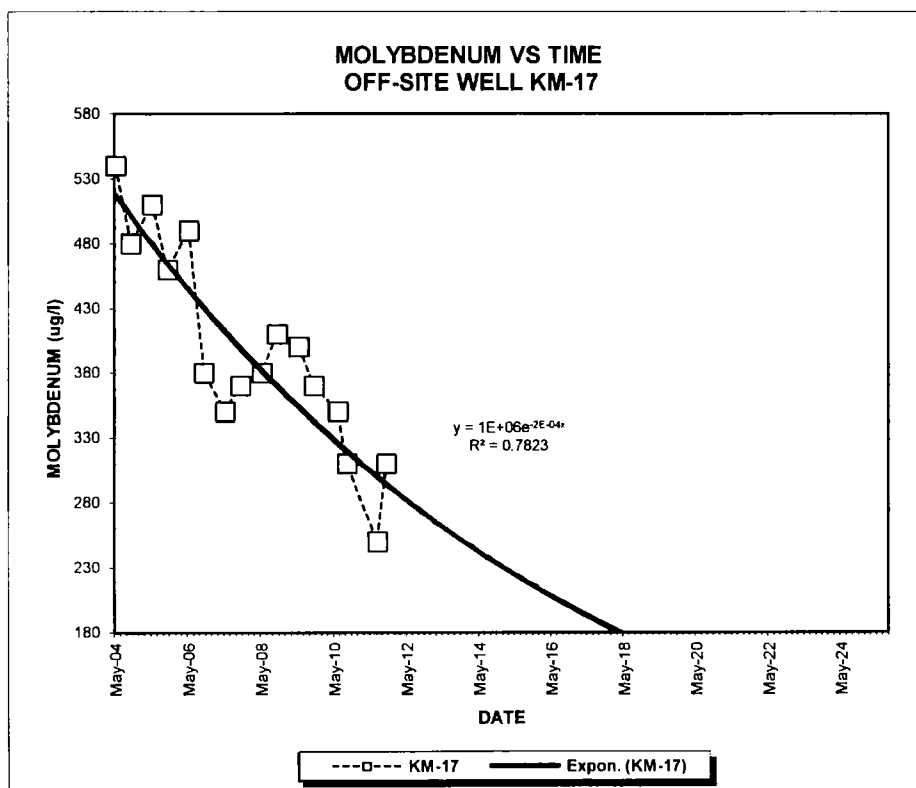
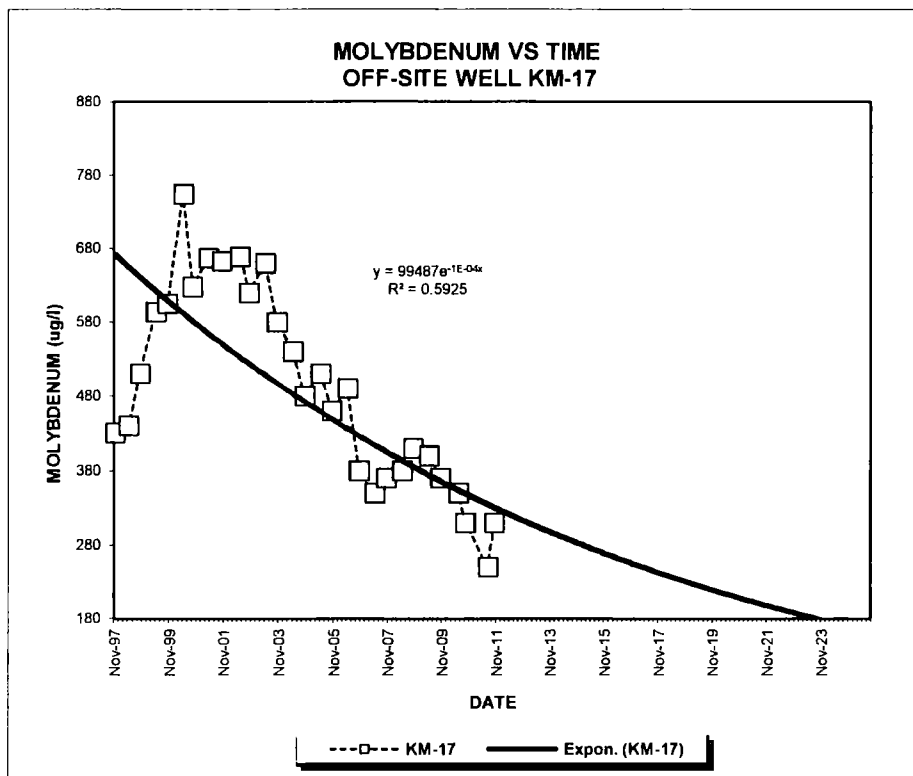


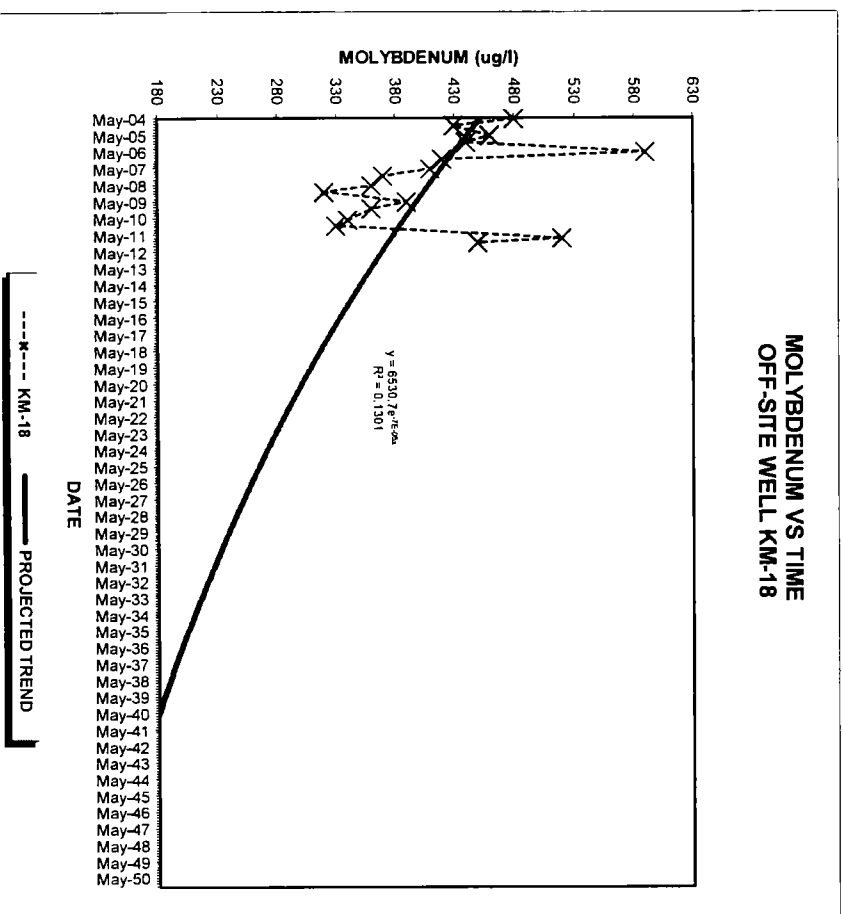
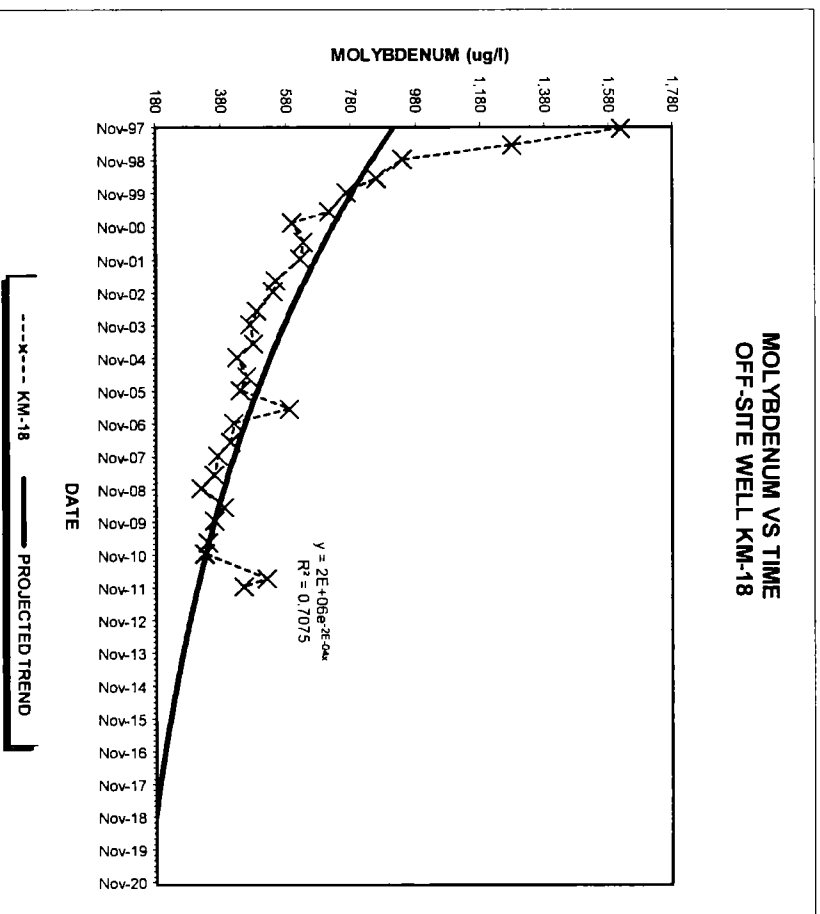


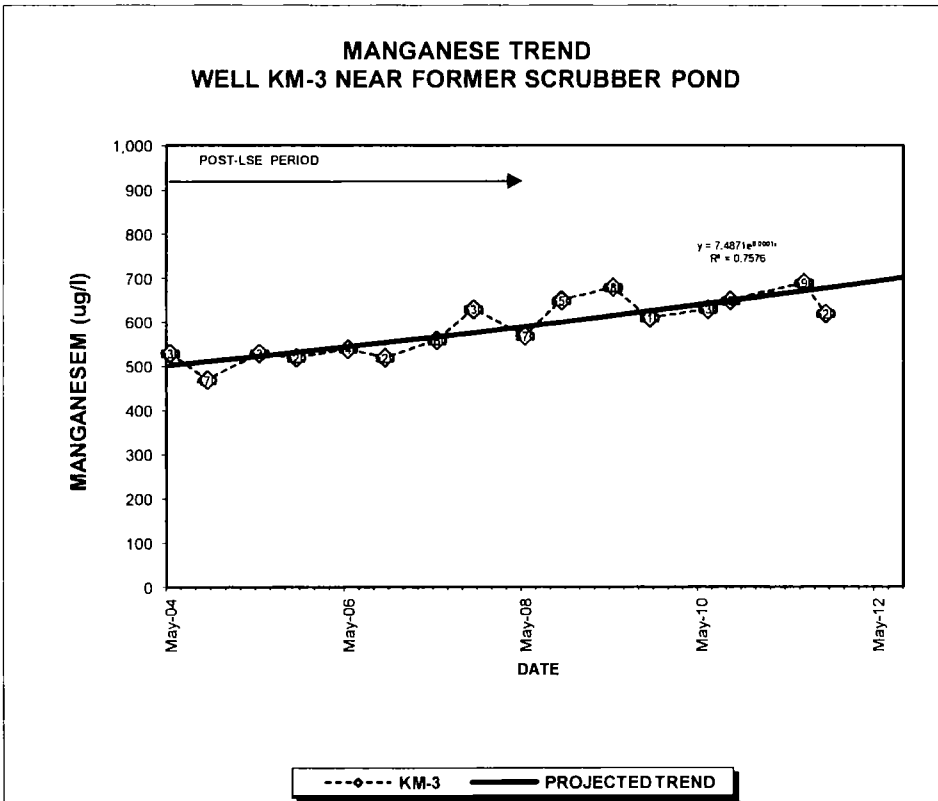
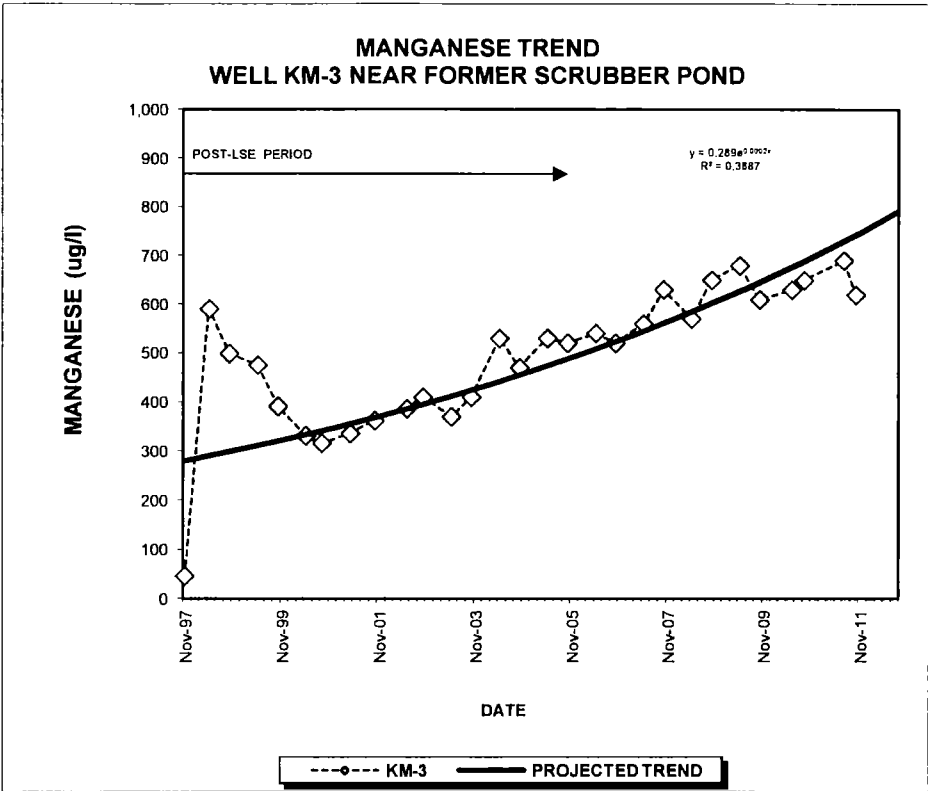


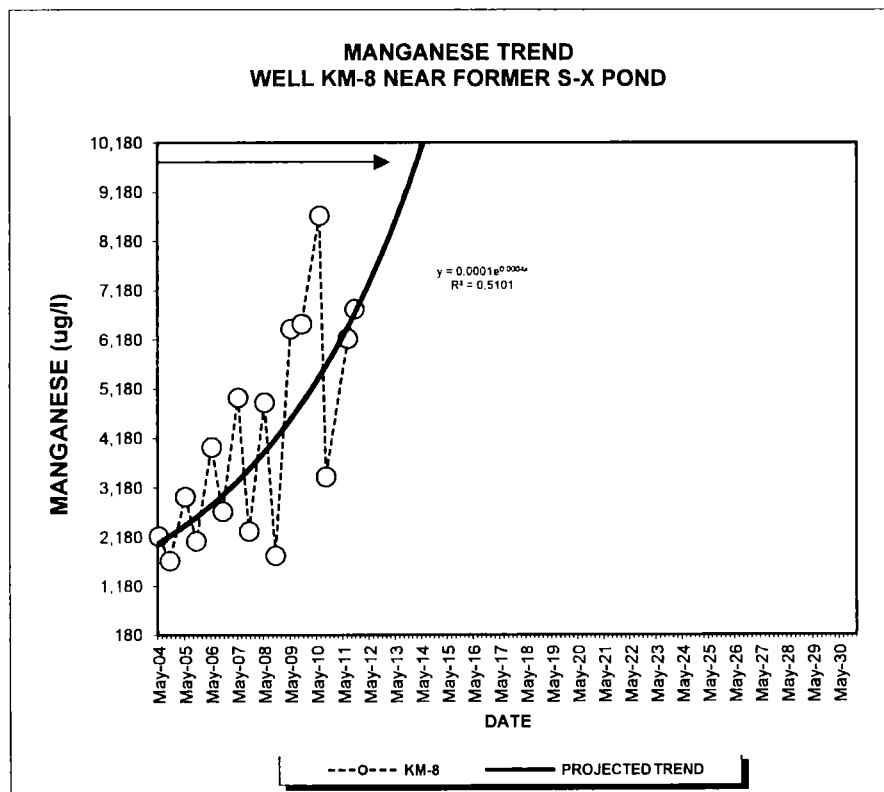
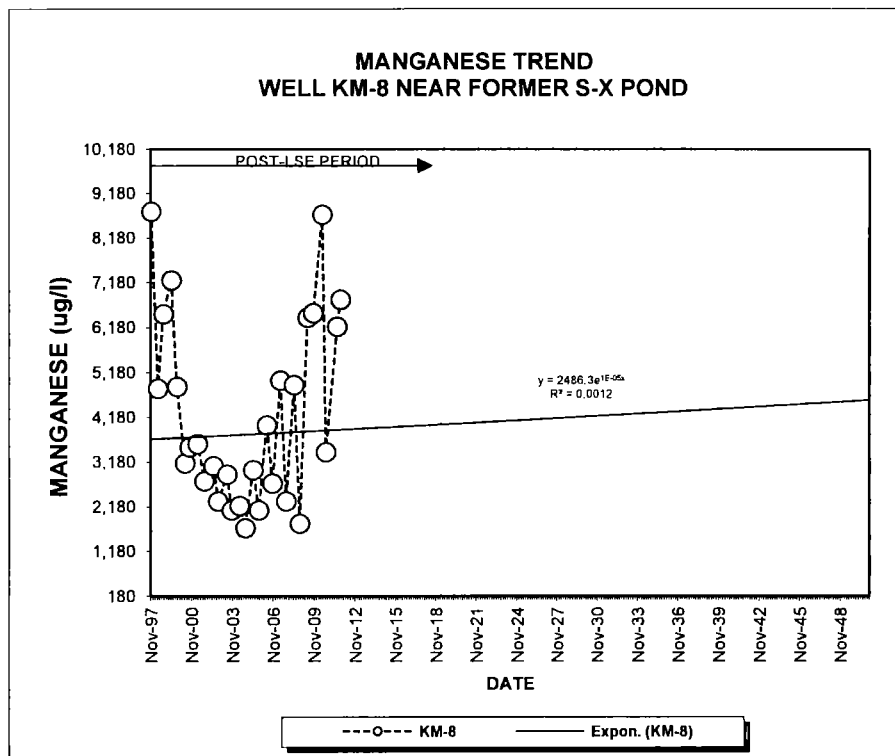


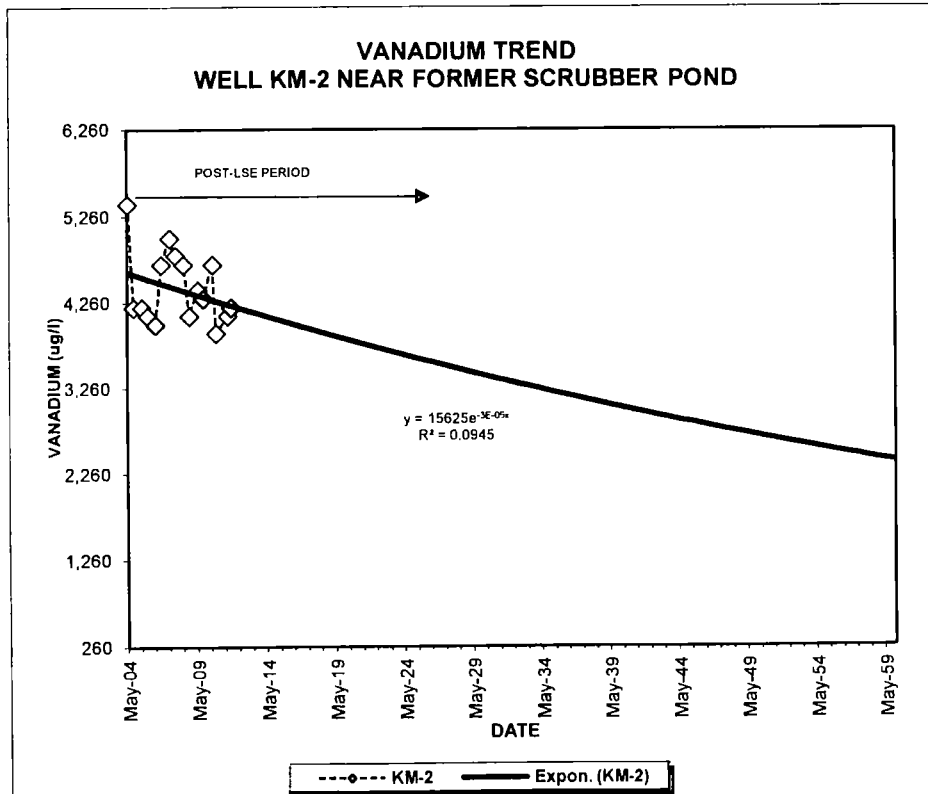
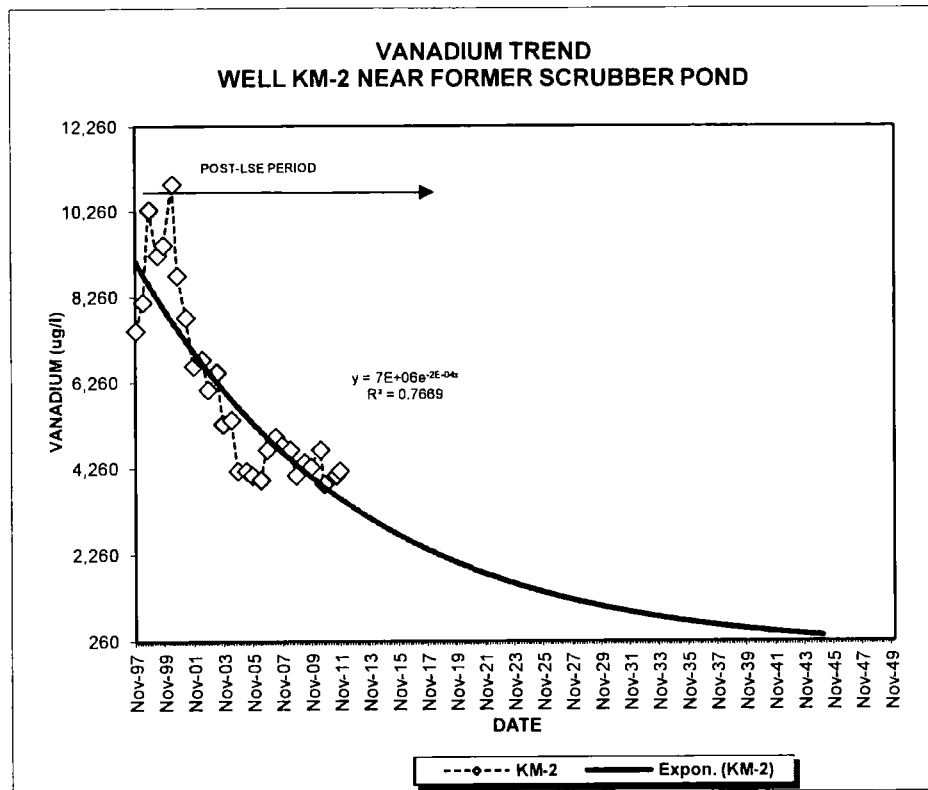


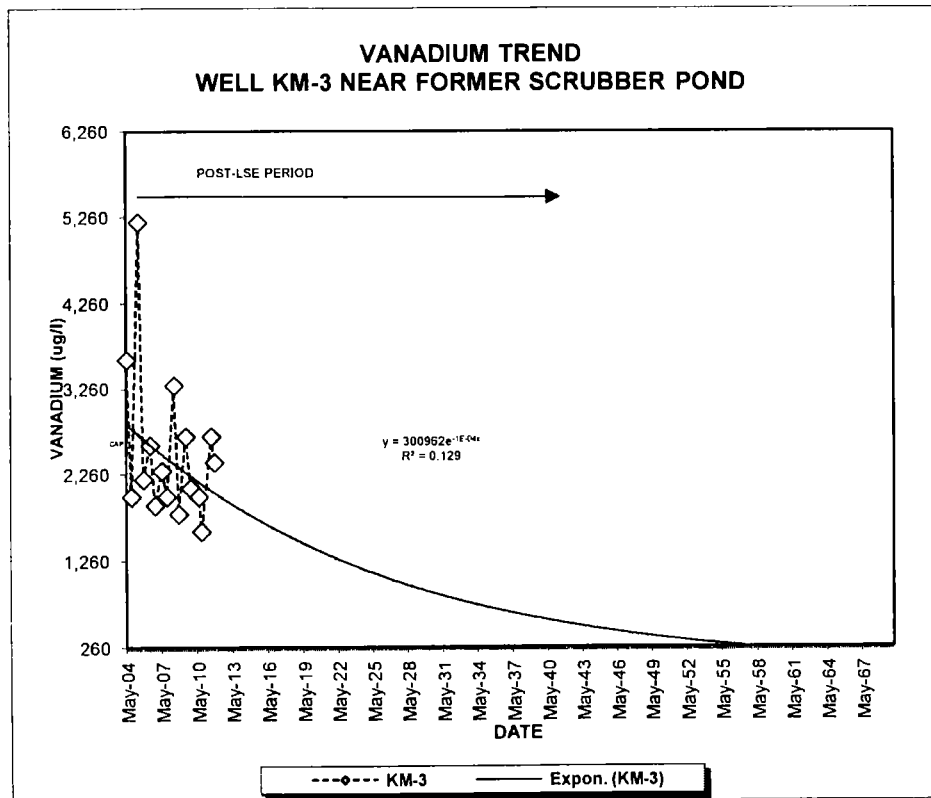
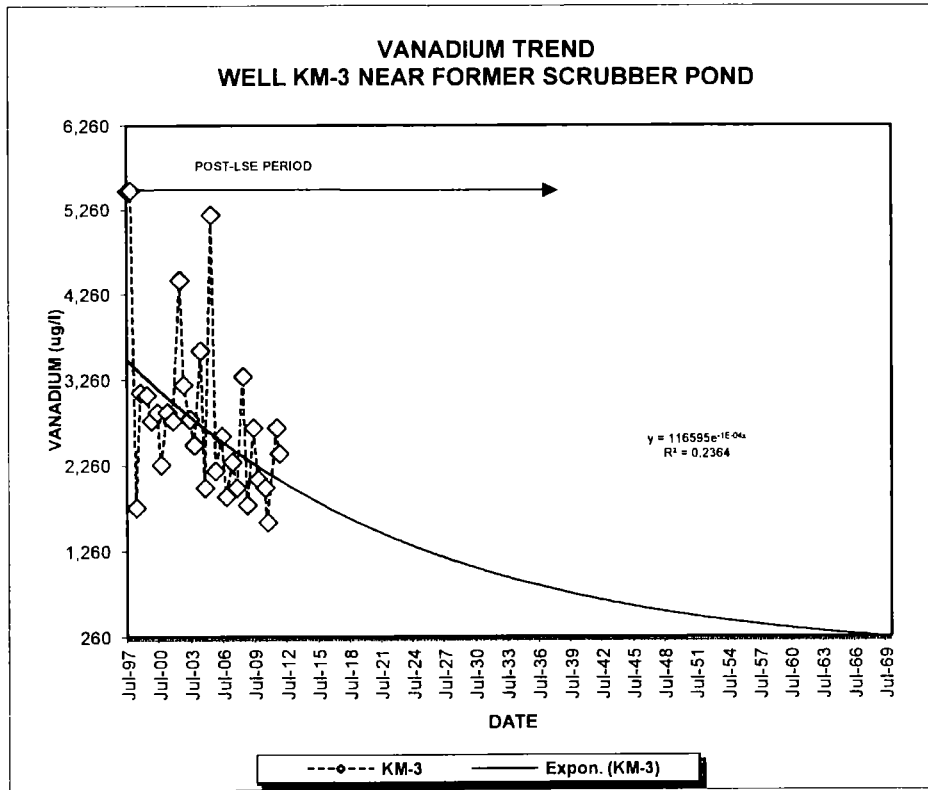


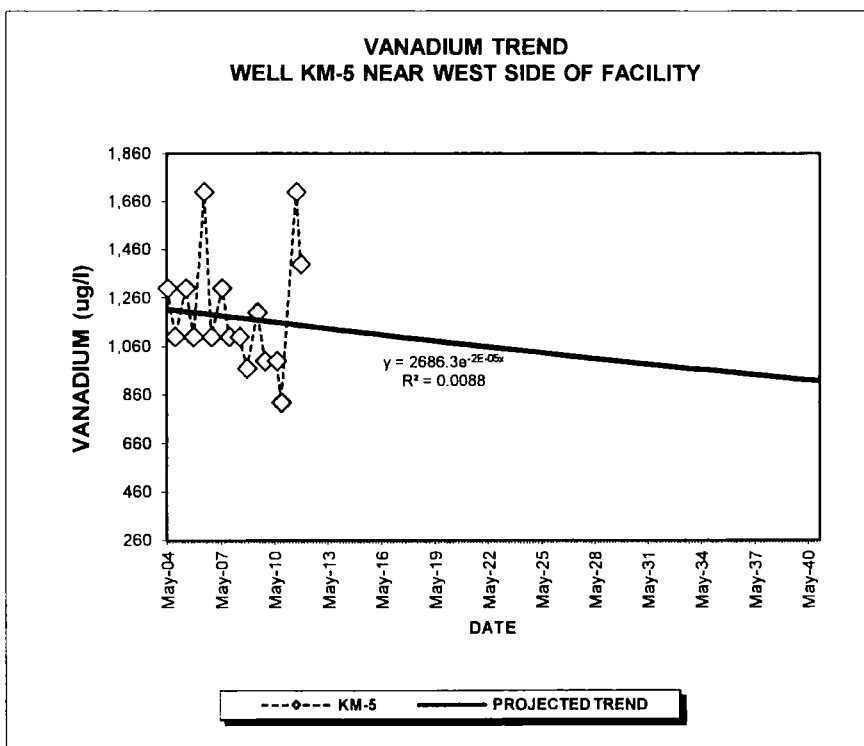
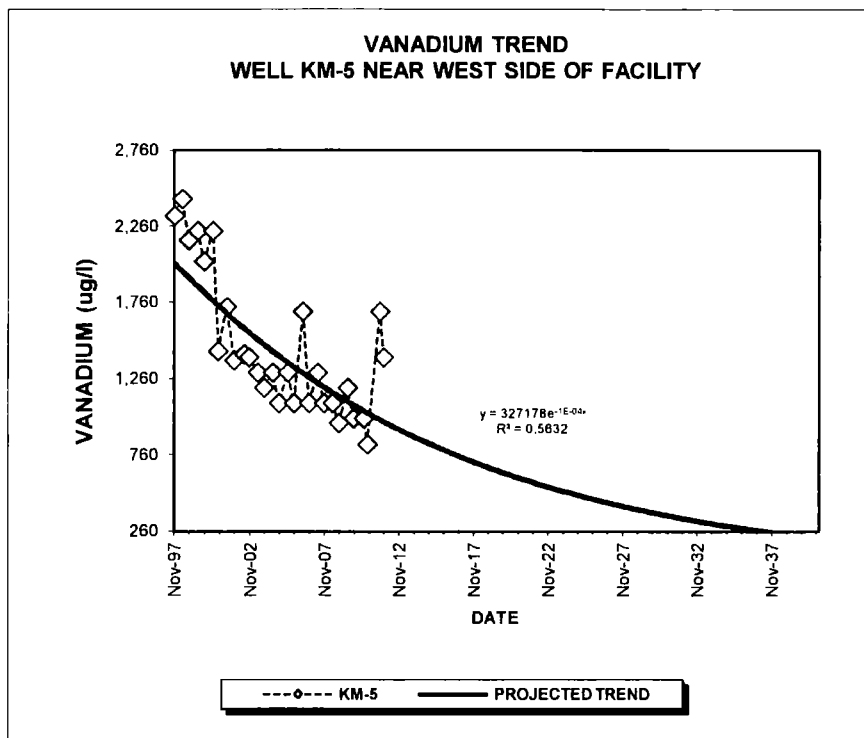
COC CONCENTRATIONS WITH TIME
AND PROJECTED TRENDS

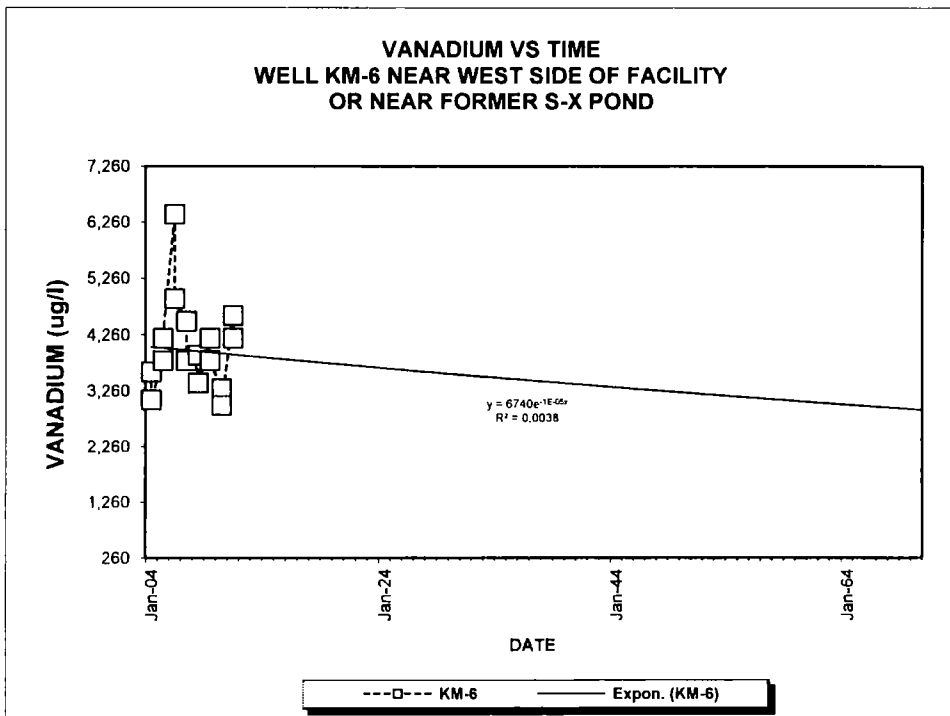
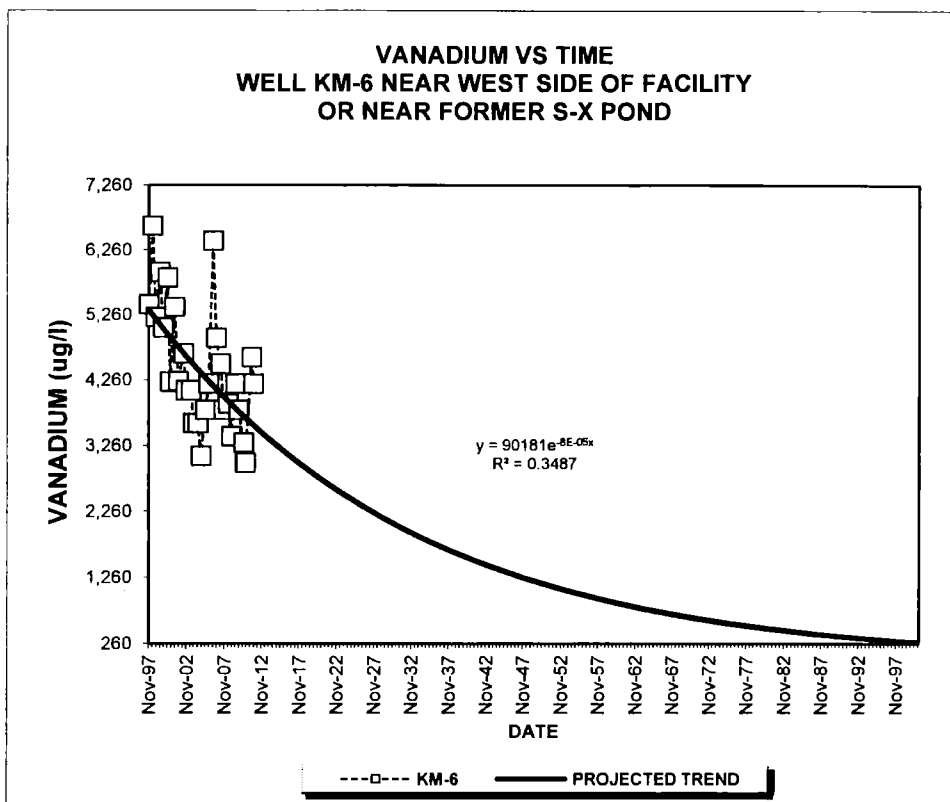


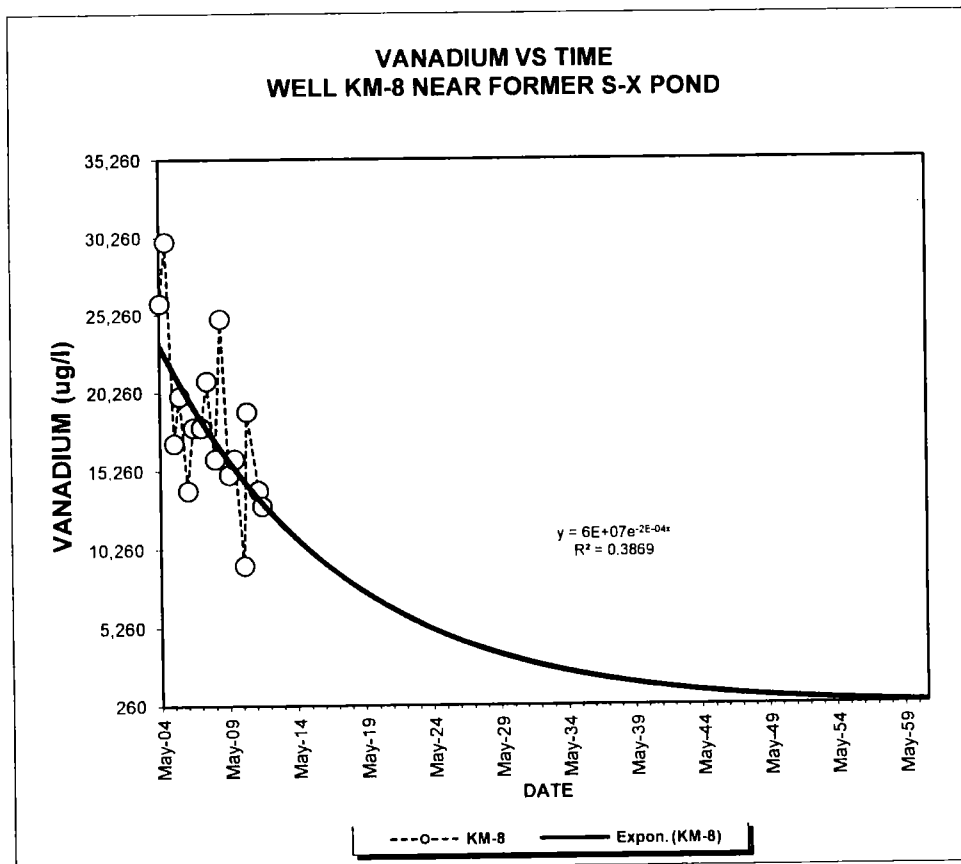
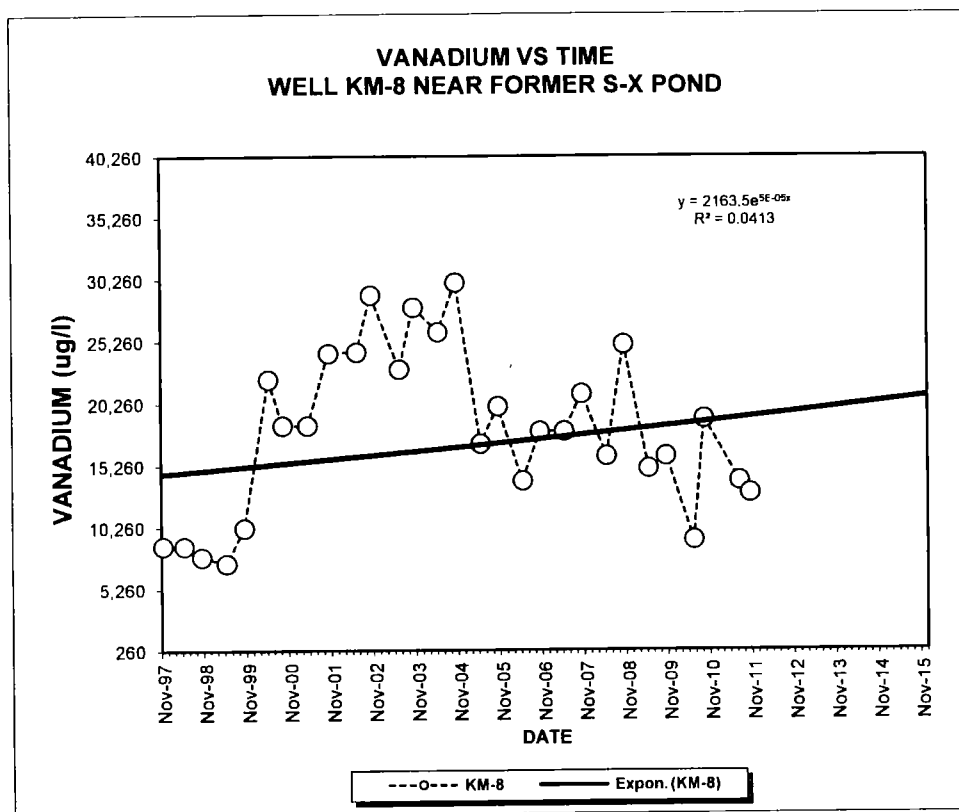


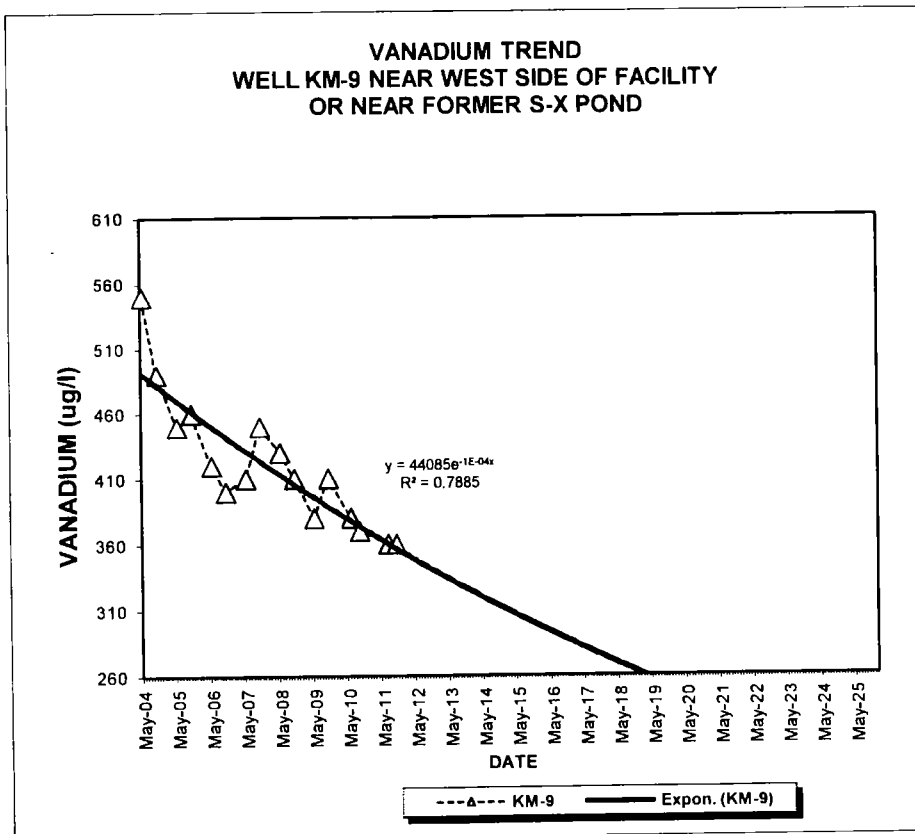
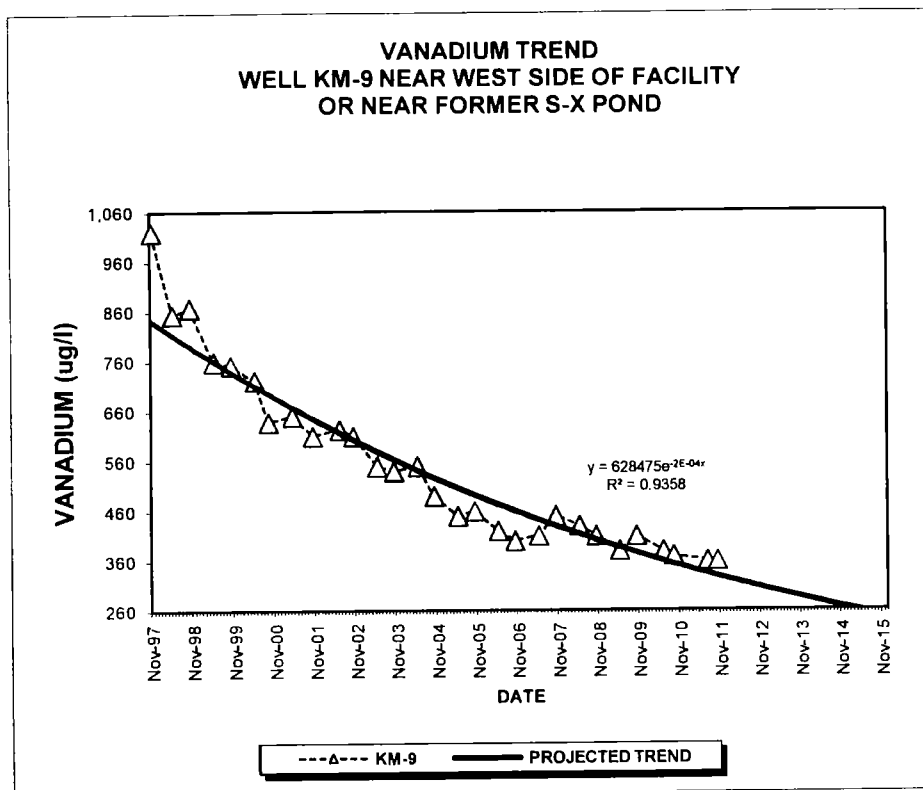


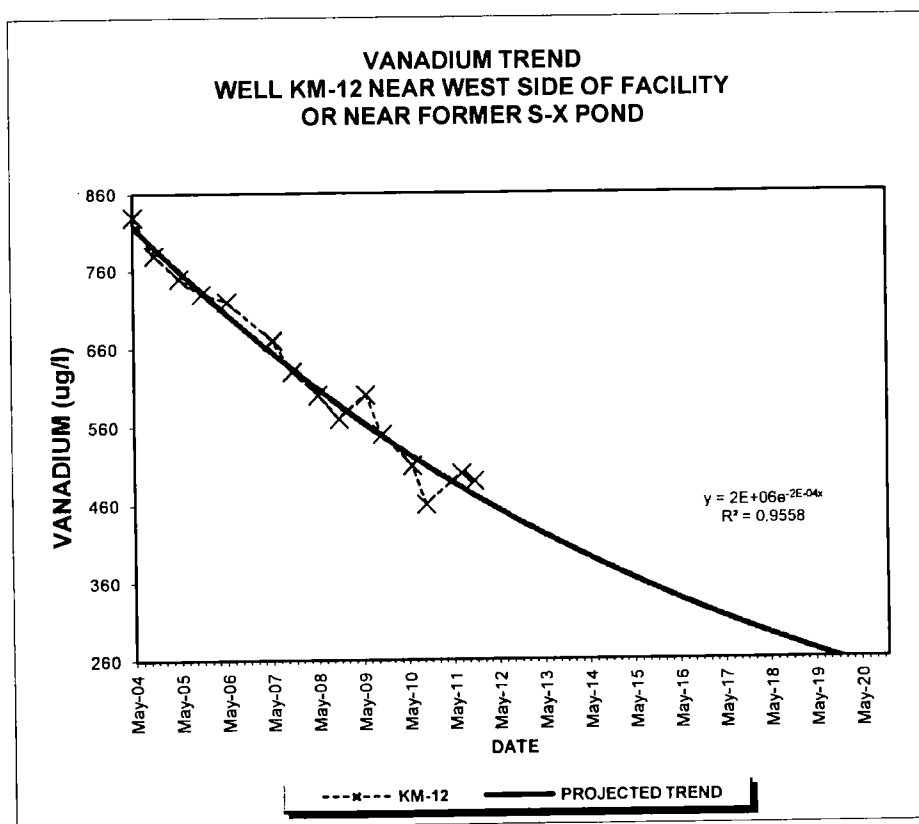
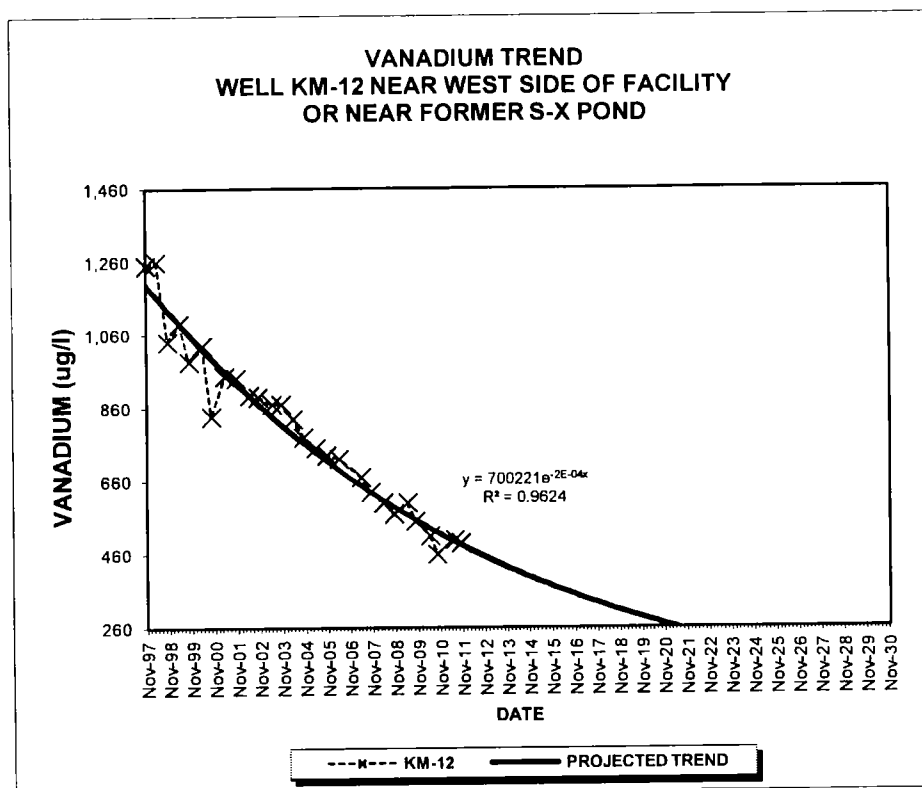


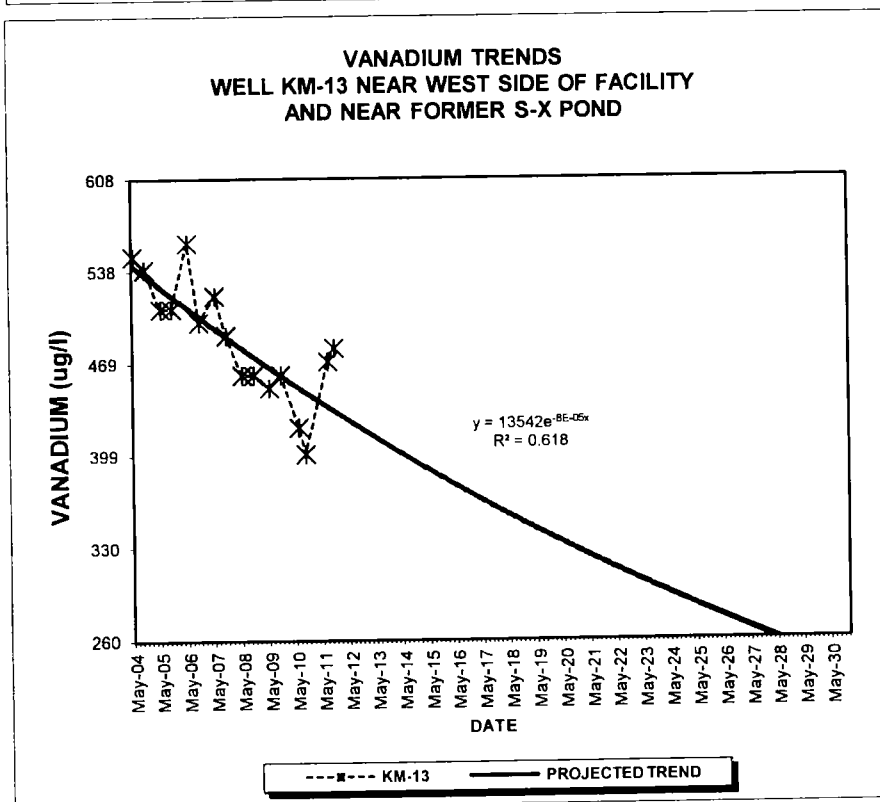
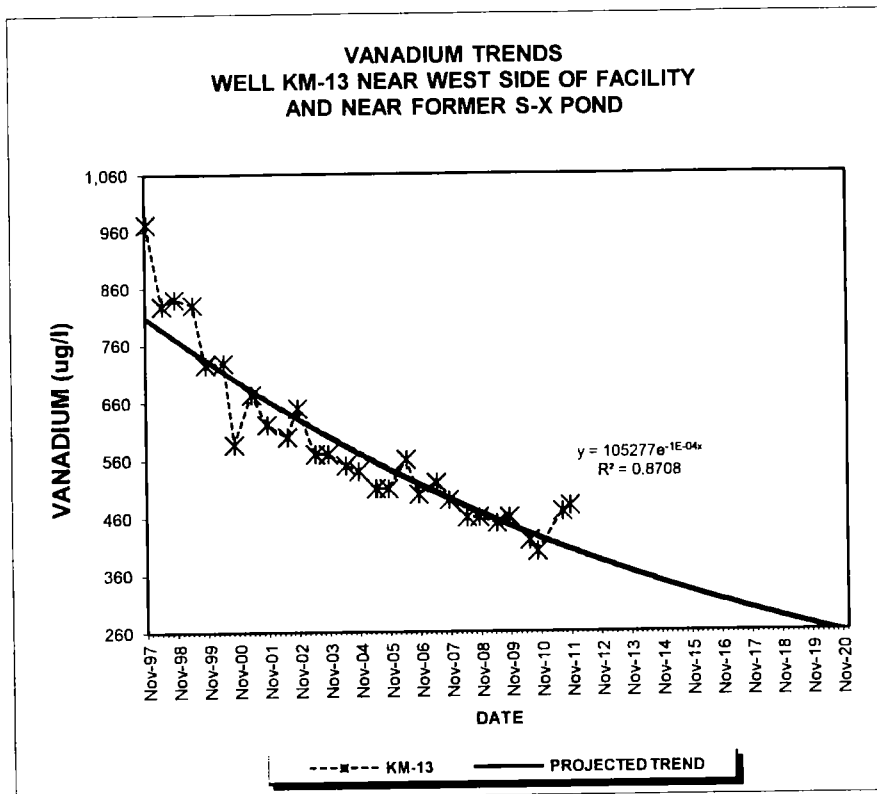


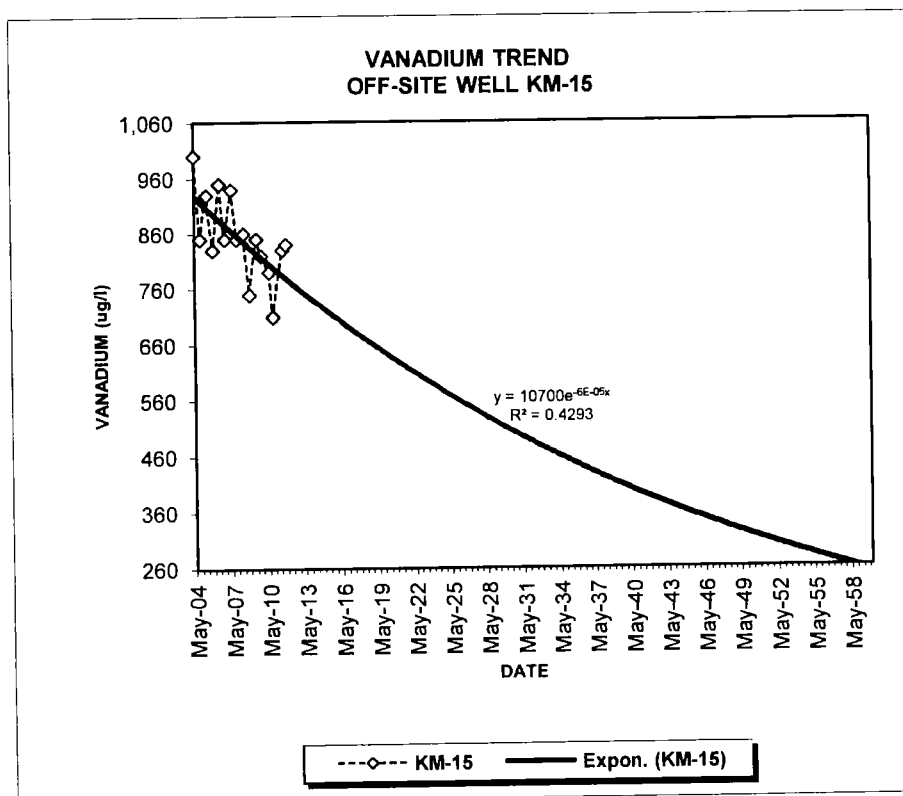
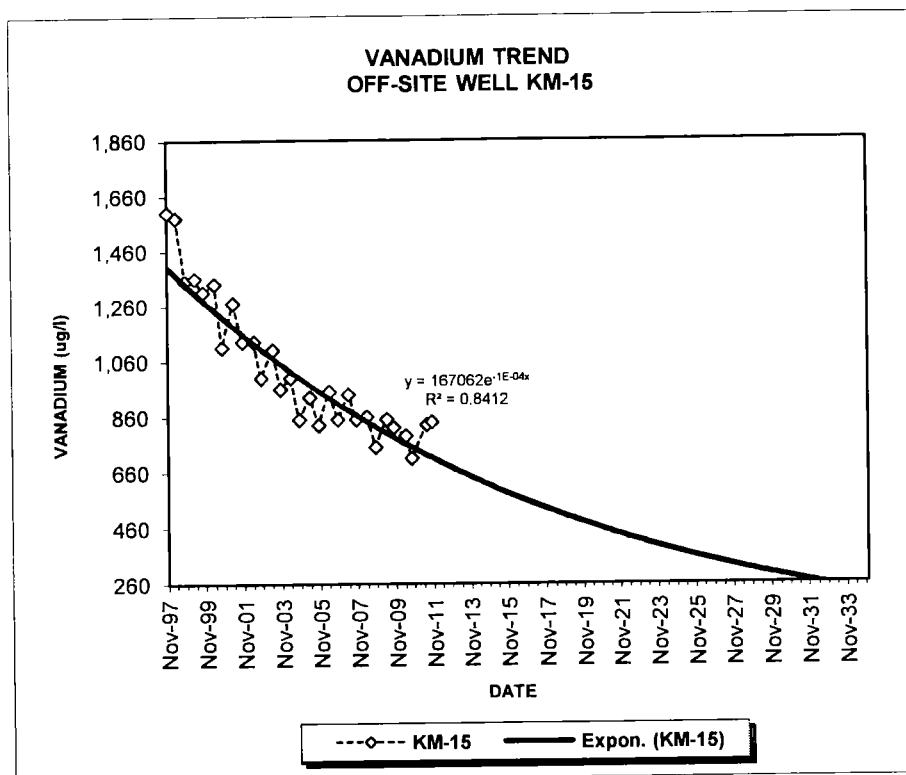


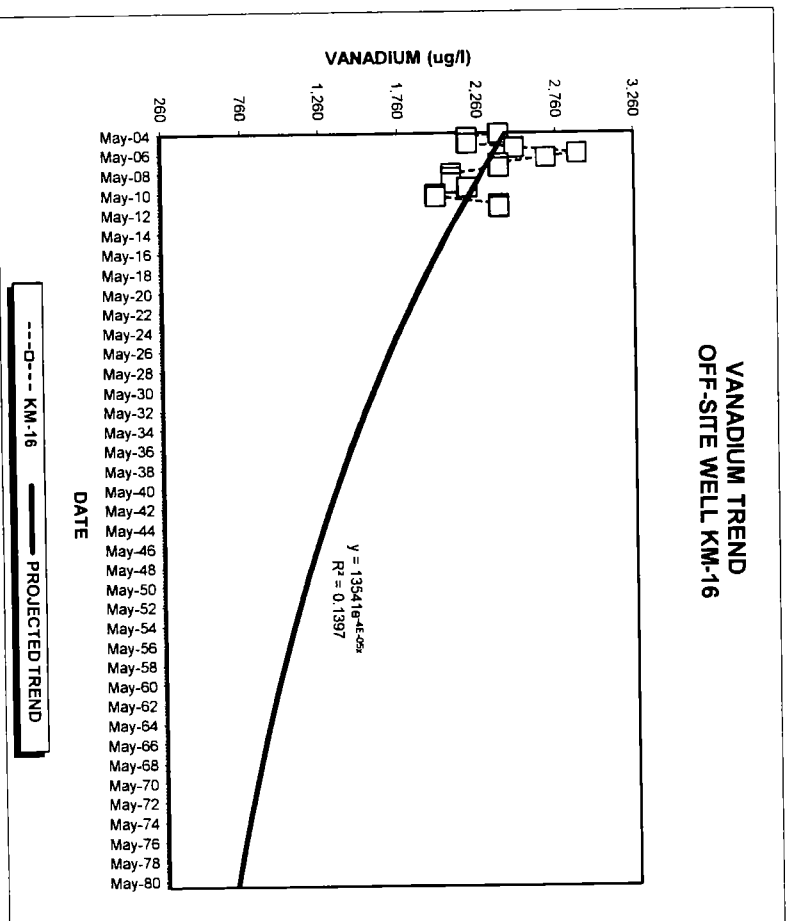
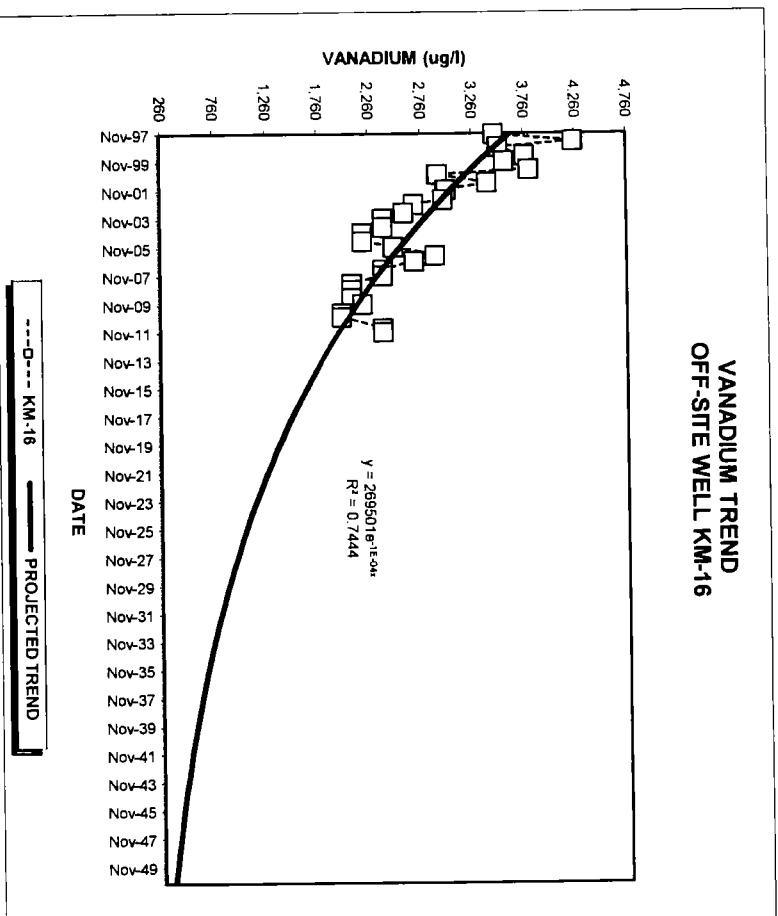


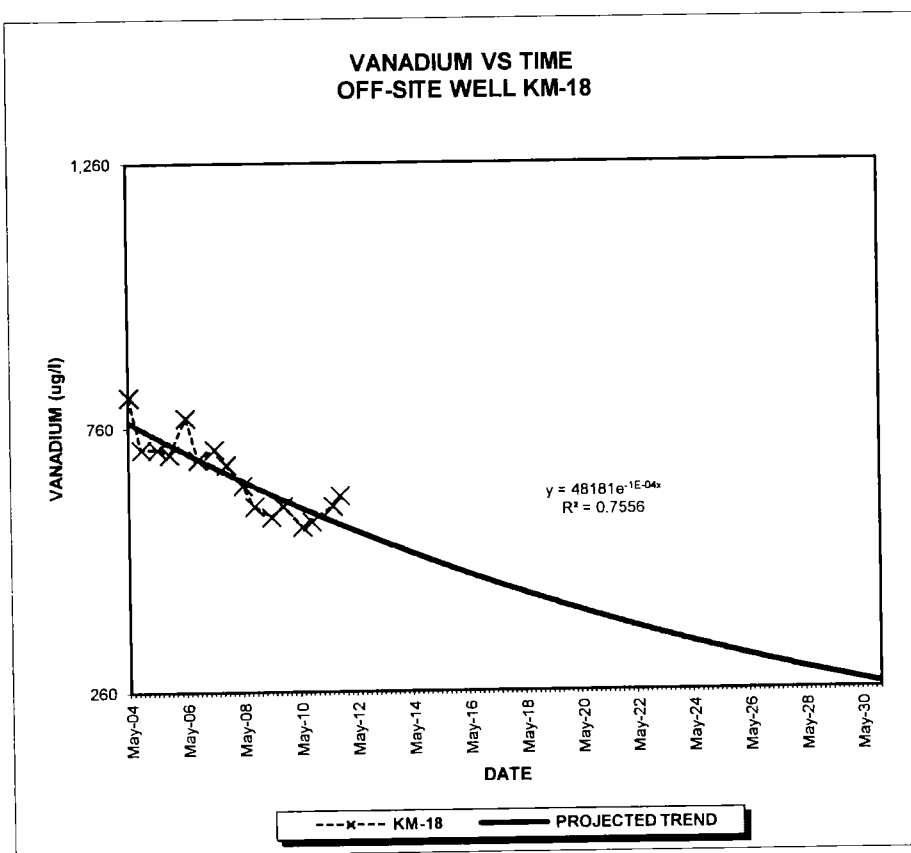
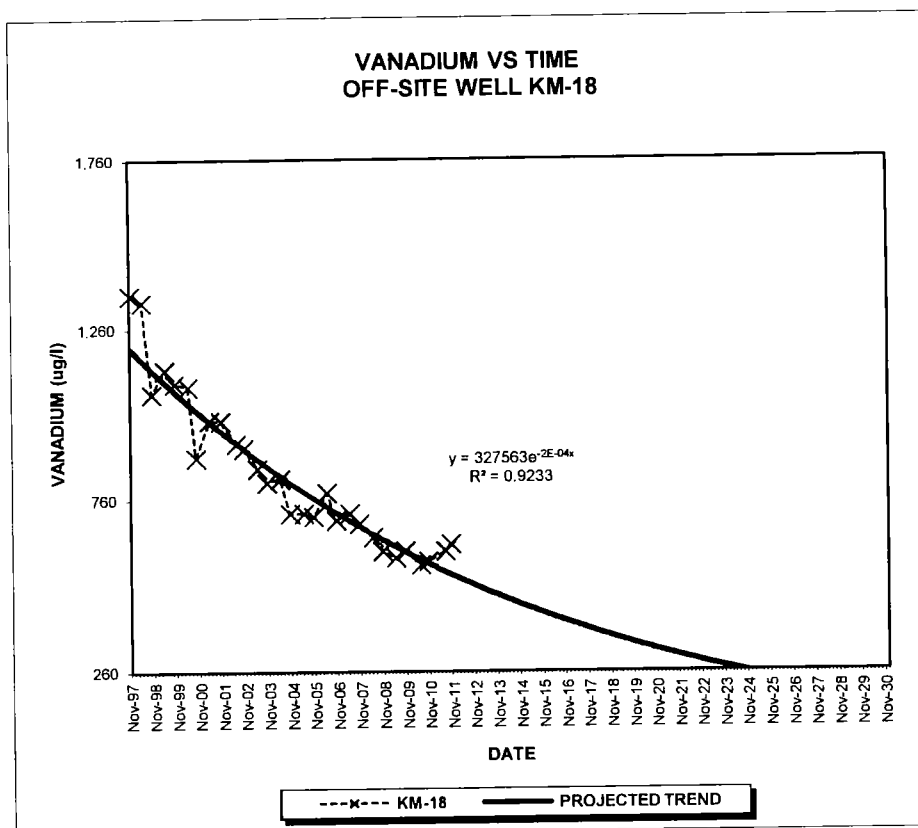










COC CONCENTRATIONS WITH TIME
AND PROJECTED TRENDS

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 SIXTH AVENUE
SEATTLE, WA 98101

TARGET SHEET

The following document was not imaged.

This is due to the Original being:

_____ Oversized

 X CD Rom

_____ Computer Disk

_____ Video Tape

_____ Other: _____

**A copy of the document may be requested from the Superfund Records Center.

Document Information

Document ID #: 1420214
File #: KMCSF 5.2 v. 2
Site Name: Kerr-McGee

2012 Annual Comprehensive Report of Ground and Surface Water Quality
Greenfield Environmental Multistate Trust
Former Tronox Soda Springs, Idaho Facility